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BELGRADE, MONTANA
WASTEWATER MASTER PLAN

CLIENT

City of Belgrade
91 East Central Avenue
Belgrade, MT 59714

IN COOPERATION WITH

AE2S

ENGINEER

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JOB NO. B16-048

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0.0 Executive Summary

A wastewater Master Plan has been prepared for the City of Belgrade to provide an overview of the condition and deficiencies in the collection, treatment, and disposal systems. Improvements to the City's wastewater system, inclusive of major infrastructure upgrades and capital improvements projects during the 20-year planning period, were developed based on future growth and existing deficiencies. Properly functioning wastewater systems are necessary to protect local ground and surface waters and comply with discharge standards established by the Montana Department of Environmental Quality (DEQ) and the U.S. Environmental Protection Agency (EPA). The collection system analysis was completed prior to June 2017 and may not reflect proposed or constructed improvements past that date.

This Master Plan is the City's initial step towards grant and loan assistance for capital improvements. The evaluation and conclusions presented in this document may be included in a future Preliminary Engineering Report (PER) and associated Uniform Application for Montana Public Facility Projects. Funding applications may then be submitted to such grant and loan programs as the Montana Department of Commerce's Community Development Block Grant (CDBG) and Treasure State Endowment Program (TSEP), the Montana DEQ's State Revolving Fund (SRF) Loan Program or the Montana Department of Natural Resource and Conservation's (DNRC) Renewable Resource Grant and Loan (RRGL) Program, as well as others.

0.1 POPULATION AND GROWTH

Historic population data reported by the United States Census Bureau was collected for both the City of Belgrade and Gallatin County. Both the County and the City have seen consistent population growth. Gallatin County reported 1.77% to 3.20% annual growth between 1990 and 2010. In that same time period, the City of Belgrade saw between 2.90% and 6.74% annual growth. Based on the historic data and conversations with City personnel, it was decided an annual growth rate of 3.5% would provide an appropriately conservative basis of design.

The 2010 Census reported 7,389 people living within the City of Belgrade. A construction year of 2018 and 20-year design life were assumed throughout this Master Plan. With an annual growth rate of 3.5%, the population within the City of Belgrade is estimated to be 19,360 people in the year 2038.

0.2 REGULATORY COMPLIANCE AND DISCHARGE PERMIT

The DEQ regulates wastewater systems in the State of Montana. *Circular DEQ-2: Design Standards for Public Sewage Systems* was referenced during the evaluation of the existing facilities, including the collection, treatment, and disposal systems. Additionally, all improvement alternatives discussed throughout this Master Plan designed in accordance with Circular DEQ-2 standards.

The City of Belgrade currently has a Montana Groundwater Pollution Control System (MGWPCS) permit that grants discharge of treated wastewater to Class I groundwater. The City's current permit mandates the groundwater nitrate concentration at the end of each mixing zone is not to exceed the human health standard of 10.0 mg/l.

The City has three permitted outfalls, IP Bed A, B, and C. A non-degradation analysis for each outfall was performed by the DEQ during the City's most recent permit renewal process. In order to maintain acceptable groundwater concentrations, the DEQ has limited the total nitrogen (TN)

loading to 72 lb/day, 72 lb/day and 74 lb/day for IP Beds A, B, and C, respectively. A meeting with the DEQ Water Protection Bureau of February 8, 2017 indicated effluent limitations are not likely to change during future permit renewals, provided the treatment plant can continue to produce effluent quality to prevent exceedances of effluent loading limits.

0.3 COLLECTION SYSTEM CONDITION AND RECOMMENDATIONS

The collection system consists of gravity collection mains, manholes, lift stations, and force mains. Most of the system discharges to a sewer vault on Dry Creek Road before entering the outfall sewer that feeds the Wastewater Treatment Plant. Two subdivisions northeast of the treatment plant discharge wastewater through a force main which terminates at the end of the outfall sewer. In general, the collection system is in good condition with isolated issues including older, clay tile sewer mains around West Main Street and issues at the Cruiser and Gallatin Farmers Lift Stations. Engineer's estimates of probable cost were prepared for improvements at each lift station: $640,000 for the Cruiser Lift Station and $510,000 at the Gallatin Farmers Lift Station. Smaller repairs are recommended at the other lift stations to address sensor and SCADA issues and to provide bypass pumping connections recommended by DEQ.

Seven future planning regions were delineated and referenced to develop collection system improvements including design flow rates, gravity trunk main sizing, lift station location, and force main diameter. The areas of future growth between the City limits and planning boundary were identified and delineated through discussions with City personnel and by reviewing property ownership and aerial imagery. The design peak hour flow for each future development region was estimated by applying the City's design standards and the mapped zoning. Future gravity mains, lift stations, and force mains were sized to accommodate planning region peak hour flows. Improvements include a Northwest Regional Lift Station to serve areas north of Cruiser Lane, a Southwest Regional Lift Station to serve future development west of Special Improvement District #78, upsizing critical sewer crossings and interceptors, and upsizing existing lift stations. Cost estimates were not prepared for planning region improvements since, in most cases, it is difficult to predict when the development will occur and how costs may be distributed between the City and the developer.

0.4 TREATMENT SYSTEM CONDITION AND RECOMMENDATIONS

Through the course of this Master Plan, it was found that the City of Belgrade has a well maintained, properly functioning wastewater treatment system. However, the Belgrade area is expected to maintain its elevated population growth rate. Upgrades to the BWTP are necessary to provide reliable wastewater treatment as the City's raw wastewater flow continues to increase. Potential solutions were preliminarily considered; two were believed to be technically and logistically feasible. These alternatives include upgrades to the existing system and a new greenfield mechanical system. Upgrades to the existing system may include a new advanced aeration system with tertiary nutrient removal or a new SBR with biosolids storage within the existing lagoons. Possible greenfield mechanical systems include a fully mechanical SBR with solids digestion, 5-Stage Bardenpho, or MBR. Conversations with City personnel have indicated the most desirable option will result in a reliable, easily maintained system at a low capital cost. Due to the high construction cost and O&M complexity of the greenfield mechanical systems, it is recommended that City proceed with upgrades to the existing system.

Preliminary capital cost estimates suggest upgrades to the system will range from $17 million to $18 million. It is suggested the City complete a PER in the year 2020 to apply for financial assistance for the proposed upgrades. During preparation of the PER, a more detailed analysis

of optional upgrades and conversations with City staff regarding specific needs and desires can be completed and treatment system recommendations will be finalized. Due to inflation and the preliminary nature of the current cost estimate, the City of Belgrade should budget for $20 million in capital costs for the upgrades. This value will provide a sufficiently conservative financial plan.

0.5 DISPOSAL SYSTEM CONDITION AND RECOMMENDATIONS

Based on population projections and assumed upgrades to the treatment system, the City is not expected to need additional disposal infrastructure until the year 2032. Three feasible disposal alternatives were detailed within the Master Plan: installation of a fourth IP bed, upgrades to the existing irrigation system and construction of additional irrigation area. Evaluation of each alternative all three are considered equally beneficial. Estimated capital costs ranged from approximately $100,000 for upgrades to the existing irrigation system to $650,000 for a fourth IP bed.

It is recommended that the City prioritize more pressing system upgrades. Improvements to the disposal system should be considered by 2029, to ensure a completed system by 2032. Capital cost and needs of the City should be re-evaluated at that time.

0.6 CONCLUSIONS AND NEXT STEPS

This Master Plan provides recommended improvements to the City of Belgrade wastewater system and a general timeline for implementing the treatment and disposal system improvements. The City's wastewater treatment system is expected to reach capacity around the year 2023. It is recommended that the City's primary wastewater system planning prioritize recommended treatment alternatives necessary to ensure operations in 2023.

An independent Rate Study is currently considering infrastructure improvements to budget for recommended projects. It is expected that conventional grant and loan funding options will be considered in the Rate Study and pursued in the next funding cycle. A Preliminary Engineering Report (PER) is needed to submit for grant funding.

It is recommended that the City submit a finished PER in 2020. Grant applications submitted in 2020 will be subject to approval during the 2021 Legislative session (2023 Biennium). If the project ranks well and funding is approved, design could begin in the summer of 2021 to and bid documents ready in early 2022. Bidding should occur soon after to allow for delivery of long-lead equipment ahead of the 2022 construction season.

Recent discussions with the DNRC indicates planning grants will be available in the Fall of 2018. It is recommended the City contact DNRC and other perspective planning grant programs early to confirm funding availability and anticipated grant allowances.

1.0 INTRODUCTION

The City of Belgrade has requested an analysis of their existing wastewater collection, treatment and disposal systems, inclusive of recommending major infrastructure upgrades and capital improvement projects for a 20-year planning period. The chapters to follow include the necessary planning and engineering required to systematically address the existing and future issues regarding the City's wastewater management system.

1.1 Purpose

This Master Plan has been prepared for the purpose of identifying deficiencies within the City of Belgrade's existing wastewater collection, treatment and disposal systems. Properly functioning wastewater systems are necessary to protect local ground and surface waters and comply with discharge standards established by the Montana Department of Environmental Quality (DEQ) and the U.S. Environmental Protection Agency (EPA). Additionally, wastewater infrastructure must be adequately sized to manage peak flows. This Master Plan will address the impacts of the City's anticipated growth and increased wastewater flows on the existing infrastructure.

Improvement alternatives will be identified and evaluated to provide a prioritized list of major and minor capital improvement needs. All proposed upgrades will account for a minimum 20-year design life. A cost-effective analysis of the proposed alternatives will be compared to determine the lowest capital and operating costs in conjunction with social and environmental considerations. A conceptual design level analysis of various alternatives will be completed. Calculations and cost estimates will be presented to predict financial feasibility of the alternatives and recommended projects. Through this process, prudent and cost-effective wastewater management improvements can be selected for implementation.

This Master Plan is the City's initial step toward pursuit of grant and loan assistance for capital improvements. The evaluation and conclusions presented in this document may be included in a future Preliminary Engineering Report (PER) and associated Uniform Application for Montana Public Facility Projects. Funding applications may then be submitted to such grant and loan programs as the Montana Department of Commerce's Community Development Block Grant (CDBG) and Treasure State Endowment Program (TSEP), the Montana DEQ's State Revolving Fund (SRF) Loan Program or the Montana Department of Natural Resource and Conservation's (DNRC) Renewable Resource Grant and Loan (RRGL) Program, as well as others.

The wastewater system is owned and operated by the City of Belgrade. Contact information is as follows:

City of Belgrade
91 East Central Avenue
Belgrade, Montana 59714

1.2 Problem

The City of Belgrade's existing wastewater system is comprised of aging infrastructure. The existing collection system includes six lift stations of varying age, condition and capacity. The collection system includes newer PVC, installed in the last decade, as well as older clay tile pipe prone to root intrusion and blockages. The existing treatment system was constructed in 2004 with a 20-year design life. Two effluent disposal methods are currently available to the City, land application through spray irrigation and a series of three Infiltration/Percolation (IP) Beds.

The DEQ has set pollutant loading limits on the IP beds in the City's groundwater discharge permit.

The City of Belgrade has experienced population growth. The annual population growth rate has remained close to or above 3% since 1980; this trend is expected to remain over the design life of the proposed improvements. As Belgrade's population continues to grow, wastewater flows through the collection, treatment and disposal systems will increase. Additionally, the City has historically produced wastewater with elevated Biological Oxygen Demand (BOD) and organic nitrogen concentrations. Generally speaking, high strength wastewater increases capital costs of treatment components as well as operating costs.

Evaluation of the current system along with recommended improvements and scheduling are critical to ensure the system has sufficient capacity to manage the increased flows. Although the existing system has a history of compliance with the state and federal discharge requirements, additional treatment will also be necessary in the years to come to maintain compliance as populations and wastewater flows increase.

1.3 Scope

Thomas, Dean and Hoskins (TD&H) Engineering in partnership with Advanced Engineering and Environmental Solutions, Inc. (AE2S) was hired by the City of Belgrade to complete a comprehensive study of the City's wastewater collection, treatment and disposal systems. The scope of this Master Plan is to evaluate the effectiveness of the existing wastewater management systems and provide improvement recommendations with preliminary cost estimates and implementation scheduling.

The detailed scope of work for this Master Plan Includes:

- Projection of population and sewage flows
- Evaluation of existing collection system
- Evaluation of existing pump stations
- Evaluation of existing treatment lagoons and associated facilities
- Evaluation of existing disposal systems
- Evaluation of existing control devices and local panels
- Identification of infrastructure in need of repair or replacement
- Evaluation of viable alternatives
- Preparation of preliminary construction costs for each alternative
- Improvement recommendations and implementation scheduling

1.4 Acknowledgements

City of Belgrade personnel, including Mr. Ted Barkley-City Manager, Mr. Steve Klotz- Public Work Director, Mr. Jason Karp- Director of Planning, Mr. Clinton Holman, Mr. Paul Burkardt, Ms. Diane Eagleson and the entire City of Belgrade financial team were very helpful in providing recent data and historic records for the system in addition to assistance with facility inspections and equipment testing. Their cooperation, understanding and direction guided the recommendations in this report. The community has shown concern for the problems with their wastewater system and has a strong desire to address the problem in the most cost effective means possible. They have been very proactive in attempting to address their problems with the financial means and personnel availability at their disposal.

2.0 BACKGROUND

The City of Belgrade's wastewater system includes a network of six submersible lift stations, gravity mains and force mains, a three-celled aerated lagoon system and two disposal methods. The collection system has been designed to convey only wastewater to the treatment lagoons; a separate storm sewer system has been constructed to handle stormwater runoff. This chapter describes the planning area, population trends and applicable regulatory requirements.

2.1 Planning and Service Area

The location and physical characteristic of the City of Belgrade's planning area is described in the sections to follow.

2.1.1 Location.

The City of Belgrade is an incorporated city located in Gallatin County, just east of the Continental Divide in southern Montana. The City is situated on Interstate-90, roughly 10 miles west of Bozeman and 75 miles east of Butte. Most of the City is in Sections 1 and 12, Range 4 East, Township 1 South. The center of the City is at latitude 45.7785, longitude -111.1790, at an elevation of approximately 4,460 feet above sea level. A vicinity map is available in Figure 2-1.

The City is roughly 3.25 square miles. The planning area for this Master Plan is approximately 12.5 square miles and includes the Bozeman-Yellowstone International Airport. Figure 2-2 displays the existing City limits, the current Belgrade zoning boundaries and the selected planning area boundary. The planning area boundary was selected based on input from City staff.

2.1.2 Physical Characteristics.

2.1.2.1 Topography

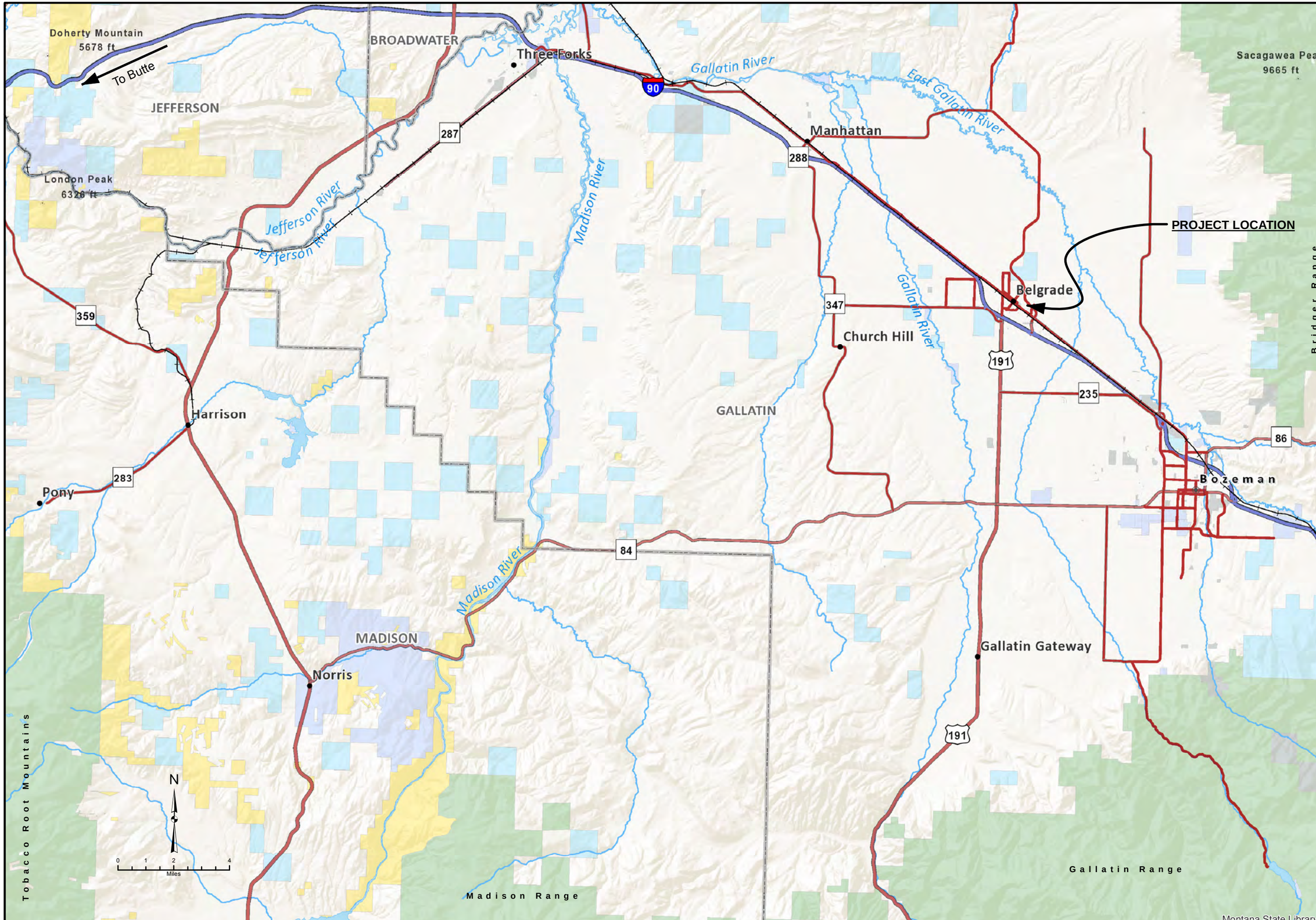
The City has relatively flat topography, generally sloping to the north. The Gallatin and Madison Mountain Ranges are south of the City, while the Bridger Mountain Range and the Tobacco Root Mountains are east and west of the City, respectively. The nearby mountains can rise to elevations as high as 10,300 feet.

2.1.2.2 Soils

A query of the United States Department of Agriculture (USDA) Natural Resources Conservation Service's (NRCS) web soil survey was completed for the planning area. Per the NRCS, most the planning area consists of soils classified as loam or cobbly loam. The detailed soils report is available for review in Appendix 2.

2.1.2.3 Surface Water

Belgrade is located between the East and West Gallatin Rivers, just south of their confluence. Several tributaries, such as Cottonwood, Gibson and Bostwick Creeks, flow past the City. Additionally, numerous irrigation ditches flow through the planning area.



J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\B16-048 Fig 2-1.bak.mxd

REV	DATE	REVISION

TD&H Engineering
406.761.3010 • tdhengineering.com
1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

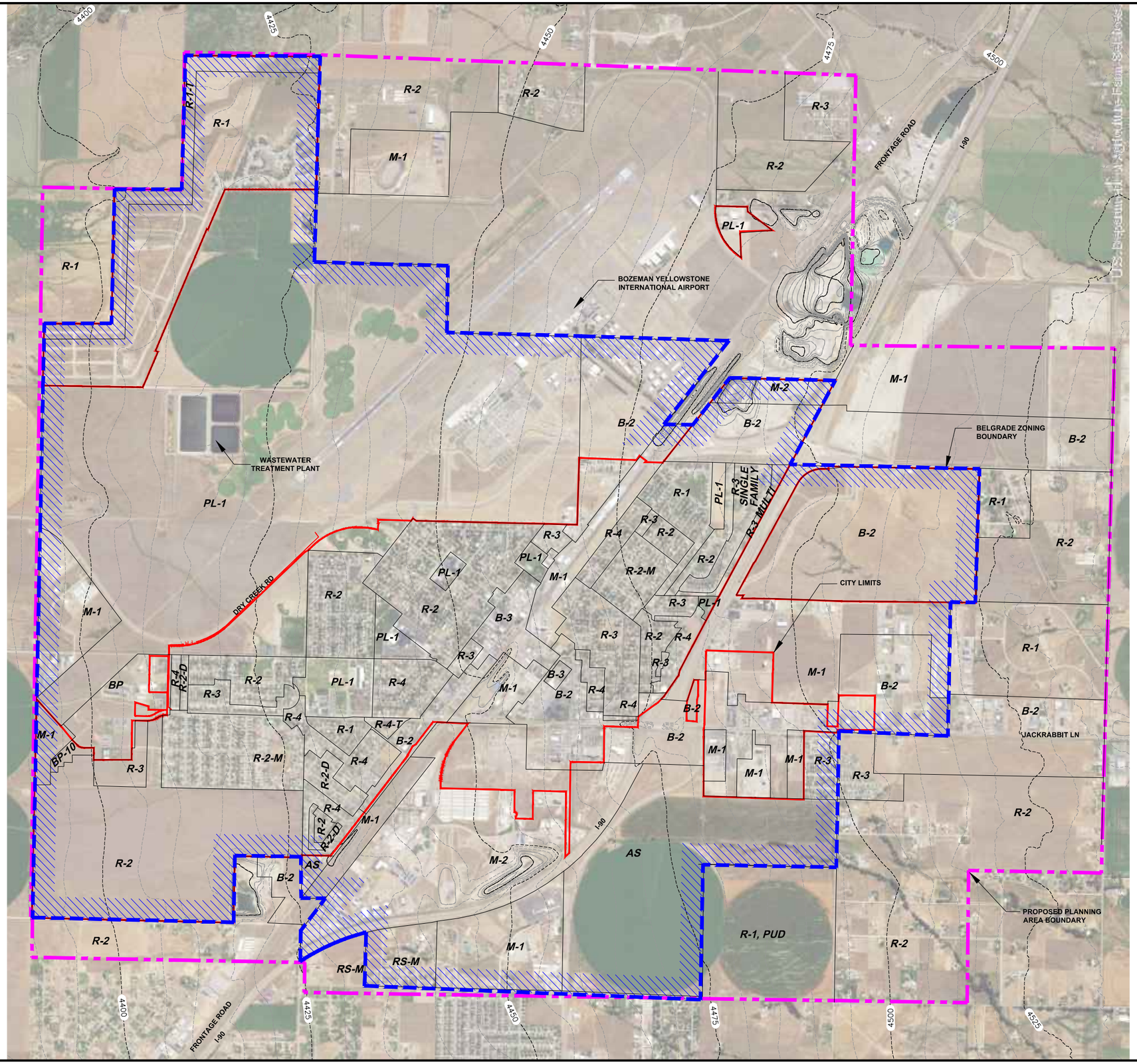
DRAWN BY: CJS
DESIGNED BY:
QUALITY CHECK:
DATE DRAWN: 04/04/2017
JOB NO.: B16-048
FIELDBOOK:

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

VICINITY MAP

B16-048 Fig 2-1.bak.MXD

SHEET 2-1



LEGEND

- CITY LIMITS
- PROPOSED PLANNING AREA BOUNDARY
- BELGRADE ZONING LIMITS
- BELGRADE ZONING BOUNDARY

0 1000' 2000' 3000'
SCALE

ZONING INDEX

ZONE	DESCRIPTION
AS	Agricultural Suburban District
BP	Business Park
BP-10	Business Park
B-2	Highway Business District
B-3	Central Business District
M-1	Commercial-Light Manufacturing District
M-2	Manufacturing and Industrial District
PL-1	Public Lands and Institutions
R-1	Residential Single Family
R-1-T	Residential Transitional District
R-2	Residential Single Family District Medium Density
R-2-D	Residential One and Two Family
R-2-M	Residential Single Family and Manufactured Homes
R-3	Residential Medium Density District
R-3-Multi	Residential Multi-Family District
R-4	Residential Apartment District
R-4-1	Residential Transitional District
RS-M	Residential Suburban Manufactured

NOT FOR CONSTRUCTION

REV	DATE	REVISION

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DRAWN BY: CJS
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QUALITY CHECK: NMR
DATE: 05-23-2017
JOB NO. B16-048
FIELDBOOK

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

PLANNING BOUNDARY AND ZONING

FIG 2-2.DWG
FIGURE 2-2

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 2-2.dwg, 5/23/2017 2:21:33 PM, CEJ

2.1.2.4 Groundwater

The City of Belgrade is in the Gallatin River drainage. The Montana Bureau of Mines and Geology's (MBMG) Groundwater Information Center (GWIC) was referenced to evaluate water levels in the area. Wells logs from 50 wells in and around Belgrade reported an average static water level of 45.3 feet below the top of the casing (TOC).

Groundwater elevations were mapped using AutoDesk Civil 3D for the City's 2011 MPDES groundwater discharge permit renewal application. Static water level data from 2003 to 2010 was utilized to map groundwater table elevations. A sample of these groundwater table elevation figures, including maps from June through September of each year of record, is provided in Appendix 2. Evaluation of aquifer conditions around the existing wastewater lagoons indicates groundwater in that area is between 27 to 32 feet below the ground surface. It was also determined that the hydraulic gradient near the wastewater lagoon is approximately 0.0044 ft/ft and slopes to the northwest.

2.1.2.5 Floodplain

The East and West Gallatin Rivers nearest the City of Belgrade have been mapped by the National Flood Insurance Program (NFIP). The majority of the City and planning area are categorized as Zone X: areas to be outside the 0.2% annual chance floodplain, also known as the 500-year flood plain. A small portion of the northeast corner of the City and planning area is categorized as Zone A: areas within the 1% annual chance floodplain, also known as the 100-year floodplain. The Flood Insurance Rate Maps (FIRM) for both the East and West Gallatin Rivers can be found in Appendix 2.

2.1.3 Climate

The Western Regional Climate Center (WRCC) was referenced for climatologic data in the Belgrade area. Data collected from the Bozeman-Yellowstone International Airport weather station was utilized. Temperate in the Belgrade area fluctuates greatly depending on time of year. In winter months, temperatures near or below 0°F are not uncommon; while the summer time can see long periods with temperatures as high as 90°F. Precipitation usually peaks in the summer with an average of 2.53 inches in June. Snow fall in the area does not generally occur in the summer, however averages 7.2 and 8.5 inches in December and January, respectively. Table 2-1 summarizes monthly averages for temperature, precipitation, snowfall and snow depth.

Table 2-1 Climate Summary					
	Average Maximum Temperature (°F)	**Average Minimum Temperature (°F)**	**Average Total Precipitation (in)**	**Average Total Snow Fall (in)**	**Average Snow Depth (in)**
January	29.9	6.2	0.57	8.5	4
February	35.5	12.1	0.45	5.6	3
March	43.1	18.8	0.91	9.1	2
April	54.9	28.7	1.35	6.0	0
May	64.4	36.9	2.21	2.3	0
June	73.2	43.9	2.53	0.0	0
July	84.6	48.9	1.12	0.0	0
August	83.2	47.4	1.12	0.0	0
September	71.2	38.7	1.29	0.5	0
October	58.4	29.3	1.06	2.3	0
November	41.8	18	0.76	5.6	1
December	32.0	8.9	0.55	7.2	2
Annual	56.0	28.2	13.92	47.0	1

2.2 Population Projections and Planning Period

Both the City of Belgrade and Gallatin County have experienced relatively consistent growth in the past. A detailed analysis of population trends is critical to correctly assess the existing system's available capacity as well as provide accurate design conditions for future upgrades. Historic population analysis and future projections for the City of Belgrade are detailed in the following sections.

2.2.1 Historical Population and Analysis

Population trends for both the City and the County were reviewed to gain a better understanding of past growth in the area. Population information published by the United States Census Bureau is summarized in Table 2-2 along with average annual growth rates for each decade.

Table 2-2 Historic Population Data				
	Gallatin County		City of Belgrade	
	Population	Annual Growth Rate	Population	Annual Growth Rate
1890	6,246			
1900	9,553	5.29%		
1910	14,079	4.74%	561	
1920	15,864	1.27%	499	-1.11%
1930	16,124	0.16%	533	0.68%
1940	18,269	1.33%	618	1.59%
1950	21,902	1.99%	663	0.73%
1960	26,045	1.89%	1,057	5.94%
1970	32,505	2.48%	1,307	2.37%
1980	42,865	3.19%	2,336	7.87%
1990	50,463	1.77%	3,422	4.65%
2000	67,831	3.44%	5,728	6.74%
2010	89,513	3.20%	7,389	2.90%
2014[1]	97,308	2.18%	7,798	1.38%

[1] 2014 population data is considered a Census estimate

Both Gallatin County and the City of Belgrade have experienced consistent growth over the past century. Annual growth for the County has ranged from 0.16% in the 1920s to 5.29% in the 1890s. More recently, the County's annual growth rate has remained relatively constant at or above 3.00%. Since 1970, the average annual growth rate has exceeded 3.00% for three of the five decades. A noticeable decline in growth was experienced from 1980 to 1990 with only a 1.77% average annual rate. However, from 1990 to 2000 the County's growth increased to 3.44% and remained above 3% from 2000 to 2010.

The City grew at a slower rate in the early 20th century. Between 1950 and 1960, the growth rate drastically increased to nearly 6%, then peaked at 7.87% in the 1970s and remained above 4.5% until 2000. From 2000 to 2010, the growth slowed to just below 3% and is estimated to have slowed even further since 2010. The population and growth rate information is graphically presented in Charts 2-1 and 2-2 for Gallatin County and the City of Belgrade, respectively.

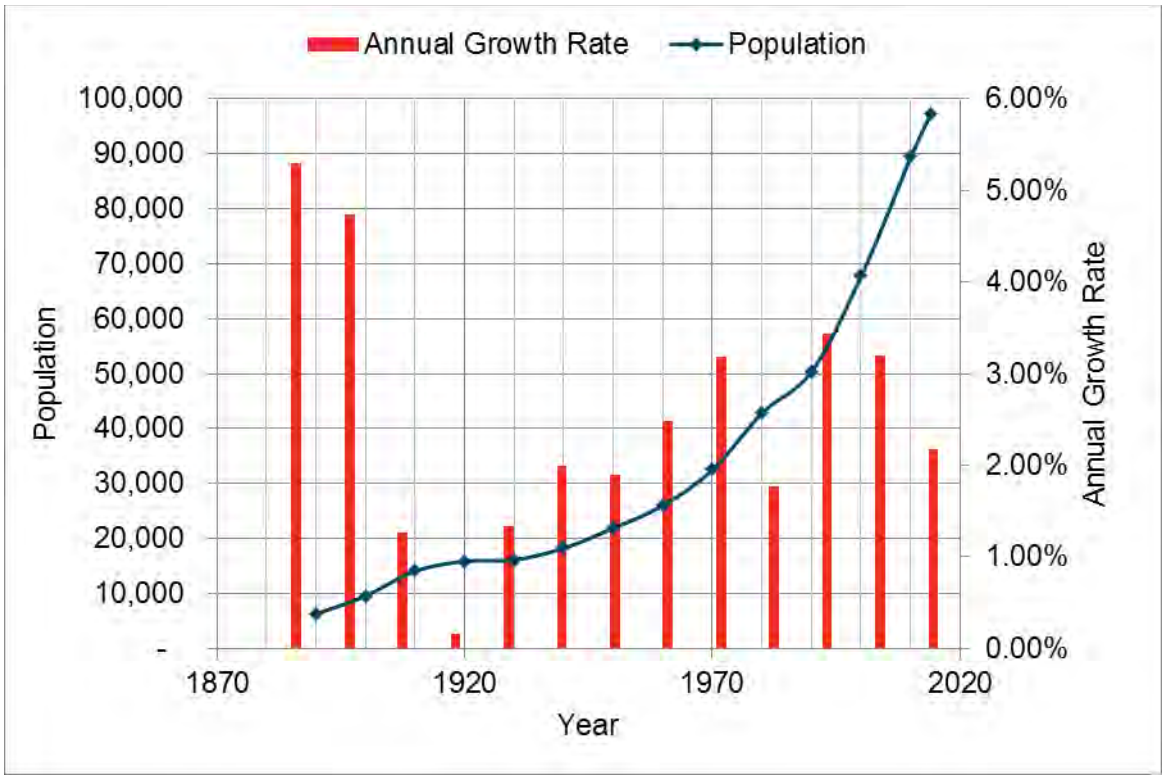


Chart 2-1: **Gallatin County Population and Average Annual Growth Rate**

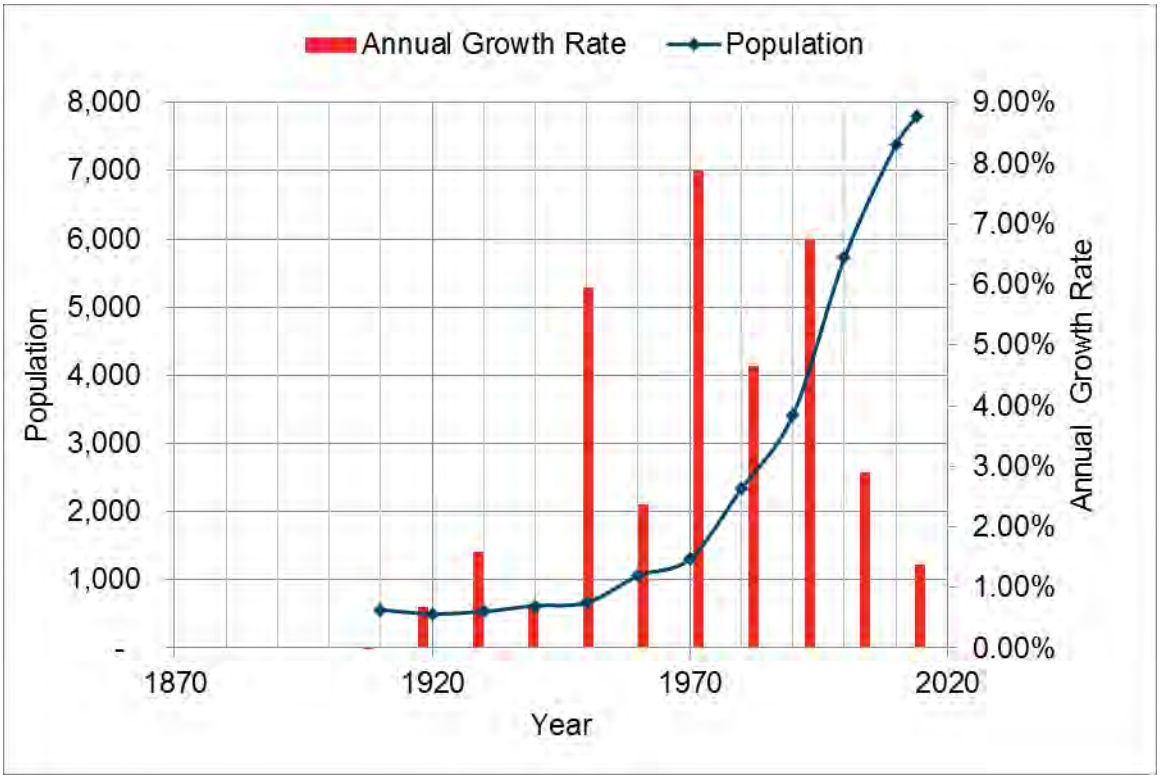


Chart 2-2: **City of Belgrade Population and Average Annual Growth Rate**

2.2.2 Future Population Planning Period and Growth Recommendations

The continual growth reported for both the City of Belgrade and Gallatin County indicates further growth in the area can be expected. Conversations with City personnel suggest Belgrade generally experiences times of rapid growth followed by periods of more consistent population. Although the City's population has grown at an annual rate of less than 3% in recent years, three of the past 5 decades have witnessed average annual growth rates exceeding 4.5%. It is believed that an annual growth rate of 3.5% will provide a conservative basis of design. With this growth rate and a 20-year planning period, the design population for the City of Belgrade is 19,360 persons. The City of Belgrade formally approved these population projections in an October 24, 2016 e-mail from City Planner Mr. Jason Karp, provided in Appendix 2. Detailed population projections are presented in Table 2-3.

Table 2-3
Population Projections

Year	Annual Growth Rate	Population Estimates
2010	3.5%	7,389
2018	3.5%	9,730
2020	3.5%	10,423
2030	3.5%	14,703
2038	3.5%	19,360

2.3 Regulatory Requirements

The DEQ is the primary regulatory agency for wastewater systems in the State of Montana. This agency reviews and approves new wastewater collection, treatment and disposal systems in accordance with *Circular DEQ-2: Design Standards for Public Sewage Systems*. Additionally, the Permitting and Compliance Division of DEQ issues and enforces permits pertaining to the disposal of treated wastewater. The following sections discuss the design and permitting considerations for the existing and future system.

2.3.1 Definitions

According to Circular DEQ-2, specific values for both hydraulic and organic loading must be provided as the basis of design for new and retrofitted wastewater facilities. The Circular's definitions for the specific design quantities are provided below.

2.3.1.1 Hydraulic Capacity Definitions

Minimum hydraulic parameters must be established to evaluate the capacity of sewer mains, lift stations, wastewater treatment plants, treatment units and all other wastewater handling facilities. Critical design parameters include design average flow, maximum day flow, peak hourly flow, peak instantaneous flow, and maximum month flow. All hydraulic parameters are expressed in units of volume per time.

- *Average Daily Flow (ADF):* The average daily volume of wastewater, over a 12-month period, to be received by a wastewater facility.

- *Maximum Day Flow:* The maximum volume of wastewater to be received by a wastewater facility in a continuous 24-hour period.
- *Peak Hourly Flow:* The maximum volume of wastewater to be received by a wastewater facility during a one-hour period.
- *Peak Instantaneous Flow:* The maximum recorded flow received by a wastewater facility over the shortest time interval consistent with the recording equipment.
- *Maximum Month Flow:* The maximum average daily flow calculated for a single calendar month, over a 12-month period.

2.3.1.2 Organic Definitions

Organic loading pertains almost exclusively to wastewater treatment facilities. As such, specific organic quantities for the design year are not required for collection system design. Quantities related to BOD, Total Nitrogen (TN) and Total Phosphorus (TP) are included in treatment facility design requirements. Organic loading is expressed in units of weight per time.

- *Biochemical Oxygen Demand (BOD_5):* The amount of oxygen required to stabilize biodegradable organic matter under aerobic conditions within a five-day period.
  - *Average BOD_5:* The average BOD_5 load received for a continuous 12-month period.
  - *Maximum Day BOD_5:* The largest amount of BOD_5 load to be received during a continuous 24-hour period.
  - *Peak Hourly BOD_5:* The largest amount of BOD_5 load to be received during a one-hour period.
- *Total Nitrogen (TN):* The summation of organic nitrogen, ammonia, nitrite and nitrate (all expressed as N).
  - *Average Total Nitrogen*: The average TN load received for a continuous 12-month period.
  - *Diurnal Peak TKN:* Total Kjeldahl Nitrogen (TKN) is the organically bonded nitrogen and ammonia present in the wastewater. The diurnal peak TKN is the largest quantity of TKN to be received during a continuous 24-hour period.
- *Total Phosphorus (TP) Loading*: The average daily quantity of the phosphorous to enter the treatment plant for a continuous 12-month period.
- *Total Suspended Solids (TSS) Loading:* TSS are solids present in the wastewater stream that may be captured and removed by a filter. TSS loading is the average daily quantity of TSS received by the treatment plant over a continuous 12-month period. TSS loading is not specifically required by DEQ-2, but should be considered during the design and evaluation of treatment systems.

2.3.2 DEQ Design Standards

Circular DEQ-2: Design Standards for Public Sewage Systems details design criteria for collection, treatment and disposal systems. The following sections briefly summarize applicable standards. Detailed evaluation of the existing system and improvement alternatives will be discussed in the chapters to follow.

2.3.2.1 Collection System

Collection system design criteria is detailed in DEQ Circular-2, Chapter 30: Design of Sewers and Chapter 40: Wastewater Pumping Stations.

Chapter 30 presents specific design criteria for both gravity and force mains. Criteria include minimum allowable pipe size and slope for gravity mains, restrictions to alignment and changes in pipe sizing, manholes, stream crossings and separation of clear water. Chapter 40 defines minimum standards for lift station design criteria including pump station structure requirements, pumps, intakes, and safety.

The existing collection system will be evaluated against applicable criteria. Additionally, all improvement alternatives will comply will DEQ regulations.

2.3.2.2 Treatment and Disposal Systems

The current treatment and disposal system, discussed in detail in the following chapters, is a partially mixed aerated lagoon system with controlled discharge to a series of IP beds and an irrigation system. Table 93-2 of Circular DEQ-2 provides criteria for this type of system. The criteria are summarized below in Table 2-4. The existing system will be reviewed against this criterion later in this Master Plan. Possible upgrades may require different criteria based on the proposed treatment and disposal.

Table 2-4
Treatment Standards for Partially Mixed Aerated Lagoons with Land Application

DEQ Circular-2 Criteria	Standard
Distance from Habitation	Minimum 1/4 mile from human habitation
Groundwater Separation	Minimum 4 feet from groundwater to bottom of pond
Bedrock Separation	Minimum 10 feet from bedrock to bottom of pond
Water Well Separation	Minimum 500 feet separation from pond to water well
Minimum Number of Cells	1-2[(1)]
Minimum System Oxygen Requirements	2.5 lbs O2/ lb BOD5 removed
Quiescent Zone Detention Time	1-2 days
Minimum Dissolved Oxygen	2.0 mg/l
Depth	10-15 feet
Minimum Detention Time Under Aeration	20 days
Maximum Seepage Rate	6 inches per year
Emergency Storage for I/P Beds	30-90 days
Winter Storage for Irrigation	[(2)]
Mixing In Aerated Cells	5-10 HP/MG

[(1)] One aeration cell if large storage cell is proposed, two if IP is proposed
[(2)] An annual month-by-month water balance must be used to determine required winter storage

2.3.3 Discharge Permit

The City of Belgrade has a Montana Groundwater Pollution Control System (MGWPCS) groundwater discharge permit issued by the DEQ. The current permit was issued December 1, 2012 and expired November 30, 2017. A completed application was submitted to the DEQ prior to the expiration date. At the time of writing this Master Plan, the current permit has been extended until a new permit can be issued.

Montana's non-degradation policy went into effect April 29, 1993. According to the current permit's Fact Sheet, the City's discharge activities do not result in a change in the water quality occurring on or before April 29, 1993. The DEQ therefore concluded Belgrade's discharge is not a new or increased source of contamination, and as such is not subject to the State's non-degradation policy. Rather, the DEQ has classified the receiving water as Class I groundwater. Class I groundwater must be maintained to provide the following with little or no treatment:

- Public and private water supply
- Culinary and food processing purposes
- Irrigation
- Drinking water for livestock and wildlife
- Commercial and industrial purposes

Discharging to Class I groundwater may not cause the following effects beyond the system's defined mixing zone boundaries.

- Violations to groundwater human health standards listed in Circular DEQ-7
- Increase of any constituent to a level deemed by the department to be detrimental, harmful or injurious to the beneficial uses of Class I groundwater.
- Decrease from the general water quality necessary to support designated beneficial uses

The water quality standards for Class I groundwater, defined in Administrative Rules of Montana (ARM) 17.30.1006 and Circular DEQ-7 were utilized in developing the permit effluent limitations. These standards state that nitrate concentrations at the end of mixing zones may not exceed the human health standard of 10.0 mg/l. For the purposes of predicting the nitrate concentration in the groundwater, the DEQ assumed the entire TN load is composed of nitrate, rather than a mixture of nitrate, nitrite, TKN and ammonia.

DEQ has set TN loading limits for each of the three outfalls, IP Beds A, B and C. Values were calculated using a mass balance equation considering volume of effluent, volume of groundwater, ambient groundwater concentration and applicable groundwater quality standards. (10 mg/l TN).

Allowable TN loading, as set by the current permit, is available in Table 2-5. A meeting with the DEQ Water Protection Bureau on February 8, 2017 indicated effluent limitations are not expected to change with future permit renewals, assuming the treatment plant can maintain TN concentrations low enough to prevent exceedance of effluent loading limits. Should the City become unable to comply with current permit limits, the department would likely consider the groundwater discharge as a new or increased source. At least for increased nutrient loading, this would trigger Montana's non-degradation policy and result in more stringent allowable groundwater concentrations.

Table 2-5 Current Permit Loading Limits		
Outfall	**Pollutant**	**Effluent Limit**
IP Bed A	Total Nitrogen (as N)	72 lb/day
IP Bed B	Total Nitrogen (as N)	72 lb/day
IP Bed C	Total Nitrogen (as N)	74 lb/day

3.0 COLLECTION SYSTEM EXISTING FACILITY REVIEW

The purpose of this chapter is to evaluate the existing wastewater demands and the City of Belgrade's wastewater collection system condition. The collection system consists of gravity collection mains, manholes, lift stations, and force mains. Most of the system discharges to a sewer vault on Dry Creek Road before entering the outfall sewer that feeds the Wastewater Treatment Plant. Two subdivisions northeast of the treatment plant discharge wastewater through a force main which terminates at the end of the outfall sewer. The analysis was completed in June 2017 and does not account for planned or installed infrastructure beyond this date.

3.1 EXISTING HYDRAULIC DEMANDS

The existing hydraulic demands were estimated from historic influent flows to the City of Belgrade's wastewater treatment plant. A 21-inch gravity main, known as the outfall sewer, conveys most of the City's wastewater to the plant. The remaining wastewater is conveyed through a force main which discharges at the end of the outfall sewer. Wastewater then passes through an open channel flow meter, in a structure called the weir box, prior to entering the treatment plant. The influent flow meter reports flow rates to the City's Supervisory Control and Data Acquisition (SCADA) system in gallons per minute (gpm) at 6-minute intervals. Flow data from January 1, 2010 to October 31, 2016 was downloaded from the SCADA system on November 1, 2016. From this data, existing average day, maximum month, maximum day, peak hour and peak instantaneous flows were calculated. This information is graphically presented in Chart 3-1. The SCADA data is available electronically on CD with hard copies of this Master Plan.

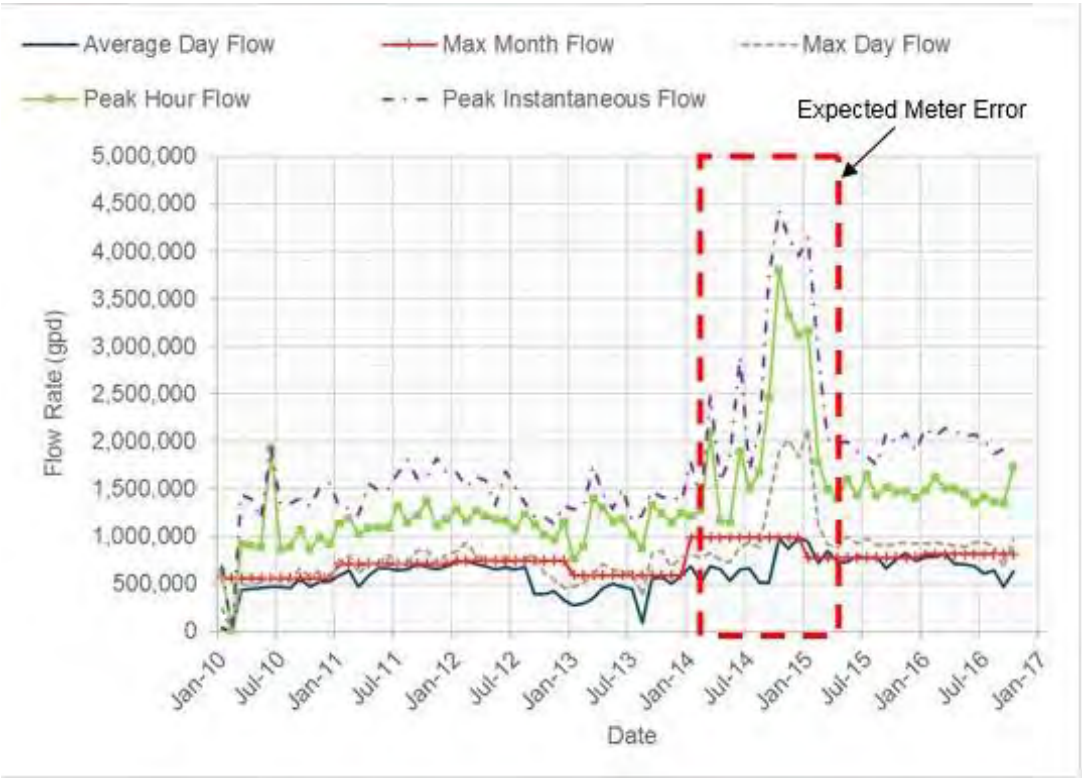


Chart 3-1: Existing Influent Flows

A general increase in flow rates, commensurate with recent population growth, has occurred over the past 6 years. A dramatic spike in peak instantaneous, peak hour and maximum day flows is reported from October 2014 to January 2015. These elevated flow measurements have been attributed to inaccurate meter measurements. Conversations with City staff suggest the treatment plant's influent flow meter had been damaged and was no longer properly seated within the control structure. The ultrasonic open channel flow meter was reportedly replaced in 2015. Average day flow rates were not significantly affected by the damaged meter readings.

Inflow and infiltration (I/I) are not expected to contribute to the system wastewater demands. According to well records from the Montana Bureau of Mines and Geology's (MBMG) Ground Water Information Center (GWIC), the static groundwater level around the City of Belgrade ranges from 22 feet to 75 feet below ground surface. The groundwater table is significantly lower than the sanitary sewer collection system and, therefore, I/I is not considered a likely source of inflow to the system.

3.1.1 Flow Verfication

M.E.T. Automation and Controls was procured to perform a flow verification and inspection of the three electromagnetic flow meters in the pump building and the flow measurement apparatus in the weir box. The verification was completed on March 27, 2017; a report documenting the findings is provided in Appendix 3. The inspection revealed several issues with the flow measurement equipment in the weir box. The current meter does not include a primary device within the flow. Rather, the meter relies on water level measurements and user-entered variables to calculate flow using Manning's equation. M.E.T. discovered that several variables were incorrect in the software, including pipe diameter and slope. The recorded flows were nearly 40% higher than the actual flow rates. M.E.T. and City personnel corrected the inputs to represent the system as accurately as possible. Regardless of the corrections, M.E.T. does not recommend the current meter type or setup. Installing equipment which also measures velocity and is submerged in the flow path has been recommended.

3.1.2 Current Wastewater Production and Average Day Flows

To determine the applicability of the available inflow measurements, the yearly average wastewater production rates for 2014-2016 were calculated based on population data. The results are presented in Table 3-1.

Table 3-1
Historic Average Day Influent Flows

Year	Average Day Flow (gpd)	Estimated Population (persons)	Calculated Wastewater Production (gpcd)
2014	689,119	7,798	88.4
2015	776,624	8,071	96.2
2016	684,468	8,353	81.9
Average	***716,737***	**--**	***88.8***

The DEQ recommends applying 90 to 100 gpcd wastewater production rates for design flows to new treatment facilities. Previous Design Reports and Facilities Plans have reported 86 gpcd

as a standard for Belgrade's production rate. Production rates from 2014 to 2016 range from 81.9 to 96.2 gpcd and averaged 88.8 gpcd. Although these values are believed to be high based on the previously discussed meter verification reports, they are not outrageously high when compared to DEQ standards and Belgrade's previous design conditions. Therefore, these values are considered to provide reasonably conservative estimates of the existing flows. Based the above analysis, the current ADF for the BWTP is estimated to be 716,737 gpd.

3.1.3 Existing Flow Rates

Peaking factors for maximum month, maximum day, peak hour and peak instantaneous flows were estimated based on SCADA flow data presented in Chart 3-1. The procedures followed during the peaking factor analysis are included in Appendix 3. Data from October 2014 to January 2015 was not included in the analysis due to the dramatic increase in flow rates attributed to the damaged meter. Table 3-2 summarizes the peaking factors and existing flow conditions.

Table 3-2
Existing Flow Rates

Demand	Average Peaking Factor	Flow Rate (gpd)
Average Day	---	716,737
Maximum Month	1.44	1,032,101
Maximum Day	1.99	1,426,307
Peak Hour	3.30	2,365,232
Peak Instantaneous	4.19	3,003,128

The maximum month, maximum day, peak hour and peak instantaneous peaking factors for the City of Belgrade have been defined as 1.44, 1.99, 3.30 and 4.19, respectively. Multiplying these peaking factors by the existing average day flow of 716,373 gpd, the existing maximum month flow rate is 1,032,101 gpd, the maximum day flow rate is 1,426,307 gpd and the peak hour and peak instantaneous flow rates are 2,365,232 gpd and 3,003,128 gpd, respectively.

3.2 GRAVITY COLLECTION SYSTEM

Belgrade's collection system consists of conventional gravity mains of varying sizes and pipe materials. Most mains are located under streets, although a few are in the alleys east of Belgrade High School. Figure 3-1 presents the known extents of the collection system and the location of the mains, manholes, lift stations, and force mains. A full-size copy of Figure 3-1 is provided with hard copies of this Master Plan.

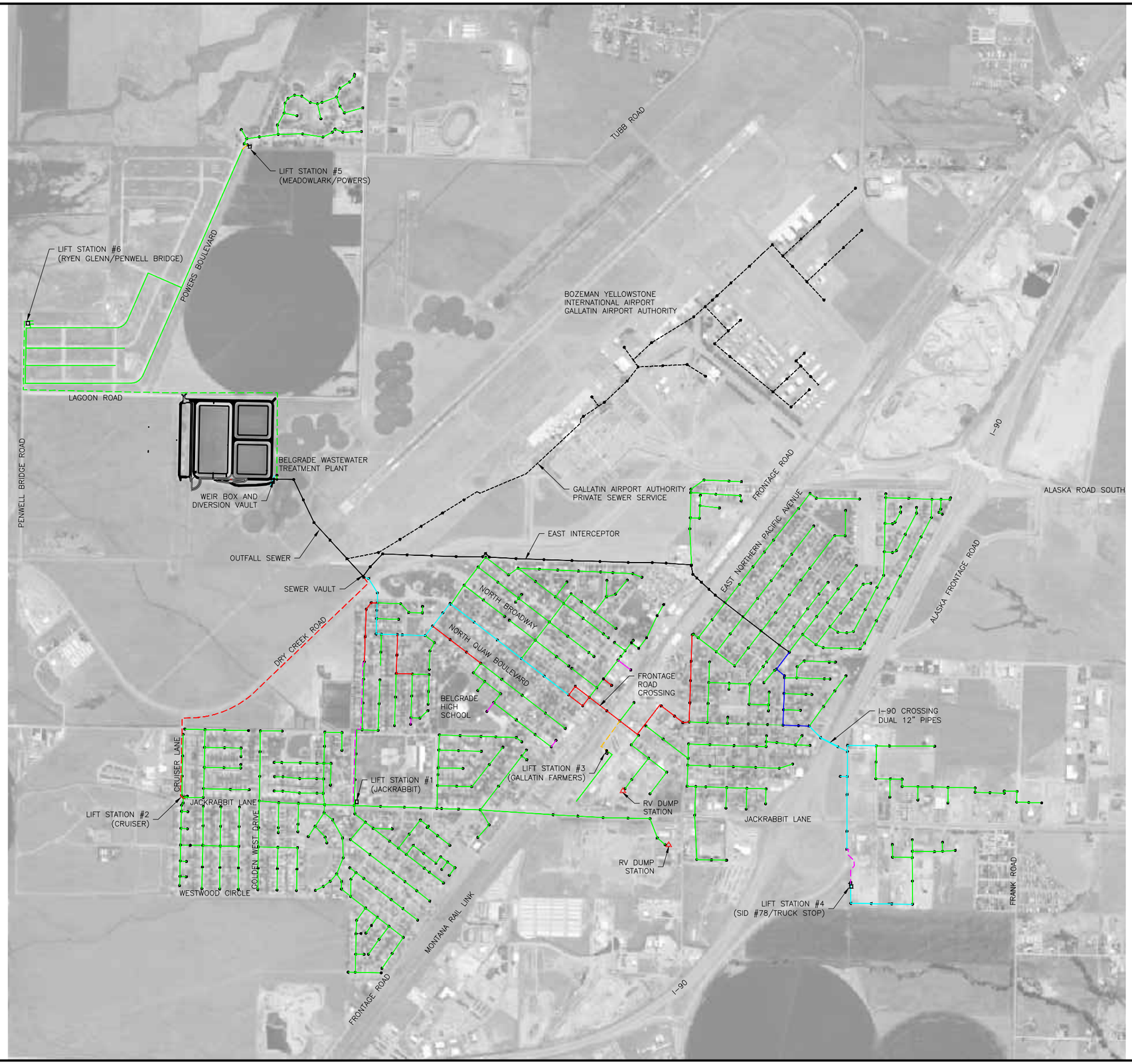
The following sections describe the known physical condition, size, and capacity of the gravity collection system; however, the City does not have a comprehensive inventory of sewer main sizes, materials, or age. The City is currently compiling a GIS database of the sewer mains and manholes in the system; however, this process is not complete and will not be finished prior to adoption of this Master Plan. When the GIS database is complete, more information will be available to assess pipe age and condition. The condition and deficiencies in the gravity collection system, as documented in this report, are based on the 1998 *Wastewater Treatment and Collection Facilities Plan* and observations by City personnel. A comprehensive infrastructure inspection has not been conducted and is outside the scope of this Master Plan.

The capacity of several sewer mains is examined in detail, including the outfall sewer, the east interceptor, and the crossing under Interstate 90. Issues with two RV dumps are also comprehensively described.

3.2.1 Condition and Physical Deficiencies

The age of the gravity mains varies throughout the City. Newer polyvinyl chloride (PVC) mains have been installed during the last decade in two subdivisions east of town, Meadowlark Ranch and Ryen Glenn Estates, and in Special Improvement District (SID) #78 south of Interstate 90 near Jackrabbit Lane. The new gravity mains and sewer manholes in these areas are in good condition. The age of the remaining gravity mains and manholes is not known; however, it is suspected that some have been in place between ten and fifty years. The 1998 *Wastewater Treatment and Collection Facilities* plan indicated the gravity mains were 25 years old at the time, so they would be 44 years old in 2017. In general, the mains and manholes are in good condition with no obvious damage or deficiencies, except in the area between North Quaw Boulevard, North Kennedy Street, West Central Avenue, and West Main Street. The 1998 *Wastewater Treatment and Collection Facilities Plan* indicates this area consists of older, clay tile pipe which is prone to root intrusion and other blockages. The *Facilities Plan* also reports a single storm drain inlet is connected to the sanitary sewer; however, the location of the inlet is unknown.

While the physical condition of the gravity infrastructure is generally good, several aspects of the layout may not comply with DEQ requirements. A review of the available sewer main mapping indicates there are locations with manhole or cleanout spacing which exceeds the requirements in Section 34.1 of Circular DEQ-2. A 2006 water and sewer design report, *Design Report for City of Belgrade SID 78 Water & Sewer Improvements*, indicates the City has equipment available to clean and maintain lengths up to 500 feet for gravity sewers 8-inches and larger.



LEGEND

- 6" SANITARY SEWER
- 8" SANITARY SEWER
- 10" SANITARY SEWER
- 12" SANITARY SEWER
- 18" SANITARY SEWER
- 21" SANITARY SEWER
- SANITARY SEWER – SIZE UNKNOWN (PRIVATE)
- 4" FORCEMAIN
- 6" FORCEMAIN
- 8" FORCEMAIN
- 10" FORCEMAIN
- SEWER MANHOLE (NOT ALL SHOWN.)
- RV DUMP STATION

0 800' 1,600' 2,400'
SCALE

NOT FOR CONSTRUCTION

REV	DATE	REVISION

TD&H Engineering
406.761.3010 • tdhengineering.com
1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY: CEVJ
DESIGNED BY: CEVJ/DDN
QUALITY CHECK:
DATE: 2017-06-19
JOB NO. B16-048
FIELDBOOK

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

EXISTING COLLECTION SYSTEM

FIG 3-X.DWG
FIGURE 3-1

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 3-X.dwg, 6/19/2017 4:35:43 PM, CEJ

3.2.2 Diameter and Capacity

The gravity collection system includes 6-, 8-, 10-, 12-, 18-, and 21-inch mains. The DEQ-required minimum sewer diameter is 8-inches; therefore, it is recommended to upsize any existing 6-inch mains during any utility replacement or street reconstruction projects. Table 3-3 presents the approximate quantities of each main size in the system. Quantities are based on the system mapping available as of May 2017. The City's GIS inventory will provide a better estimate when it is complete. Force mains are discussed in the following sections with their corresponding lift stations; however, the approximate quantity of force mains is included in Table 3-3.

Table 3-3
Collection System Inventory

Type	Pipe Diameter	Approximate Length[1]
Gravity Main	6-inches	670 LF
	8-inches	154,400 LF
	10-inches	7,500 LF
	12-inches	11,720 LF
	18-inches	1,700 LF
	21-inches	9,840 LF
Force Main	4-inches	740 LF
	6-inches	2,950 LF
	8-inches	6,760 LF
	10-inches	5,200 LF

[1]Lengths are approximate and may change after City GIS mapping is complete.

The capacity and sizing of sewer mains is based on DEQ and City criteria and is related to their slope, material, and diameter. Slopes should be sufficient to produce a scouring velocity in the pipes and prevent buildup of debris and solids. If the gravity mains are oversized, then a scouring velocity of 2-3 ft/sec may not be achieved. Circular DEQ-2 requires sewer mains be at least 8-inches and designed at the minimum slope provided in Table 3-4. Smaller diameters are allowed for certain structures where no future development is planned. The City of Belgrade *Design Standards and Specification Policy,* updated in July 2017, indicates that sanitary sewers be designed for peak hour flows plus an infiltration allowance when the pipe is 75% full. Table 3-4 presents the pipe capacity and velocity at various flow depths and at minimum DEQ slopes.

Table 3-4 Gravity Sewer Capacity at Minimum Slope							
		30% Full		75% Full		90% Full	
Sewer Diameter	DEQ Minimum Slope (ft/ft)	Flow Rate (gpm)	Velocity (ft/s)	Flow Rate (gpm)	Velocity (ft/s)	Flow Rate (gpm)	Velocity (ft/s)
6-inches	0.0060	38	1.7	178	2.5	210	2.4
8-inches	0.0040	67	1.7	313	2.5	369	2.4
10-inches	0.0028	102	1.6	474	2.4	560	2.3
12-inches	0.0022	147	1.7	684	2.4	807	2.3
15-inches	0.0015	220	1.6	1,024	2.3	1,208	2.3
18-inches	0.0012	320	1.6	1,489	2.3	1,757	2.3
21-inches	0.0010	440	1.6	2,051	2.4	2,419	2.3

City personnel have indicated no major issues with clogging or backups; as a result, it is assumed existing sewer mains are installed at sufficient slopes and are not oversized. The older, clay tile mains around West Main Street have been known to clog; however, that behavior is likely caused by root intrusion or pipe collapse.

Pipes at slopes greater than the DEQ minimum facilitate higher velocities at smaller flow rates; however, velocities which are too high may damage or displace concrete manholes and pipe inverts. Circular DEQ-2 requires special provisions for pipes with velocities higher than 15 ft/sec. The City of Belgrade is in a gently sloping area and high velocities are not anticipated in any of the gravity mains.

3.2.3 Outfall Sewer

The majority of the City's raw wastewater is conveyed to the wastewater treatment plant though approximately 2,300 linear feet (LF) of 21-inch PVC sewer pipe. As-built drawings indicate the pipe slope ranges from 0.10% to 0.24%. The outfall sewer begins at a sewer vault just east of Dry Creek Road and terminates at the treatment plant. A flow measurement vault (also referred to as the weir box) and a diversion vault are located at the downstream segment of the outfall sewer, near the head of the treatment facility. The weir box is a 60-inch precast concrete manhole with steps and manhole rim access. The diversion vault is a 72-inch precast concrete manhole with manhole rim access and steps. Two manual slide gates direct flow to either or both of the primary treatment ponds through the distribution and by-pass piping. The layout and configuration of the wastewater treatment plant piping is described in Chapter 4. Components of the outfall sewer are summarized in Table 3-5.

Table 3-5 Outfall Sewer Components	
Pipeline	
21-inch PVC	2,300 LF
Weir Box	
Structure	60-inch Precast Concrete Manhole
Inlet	21-inch PVC (south)
Outlet	21-inch PVC (north)
Meter	Ultrasonic Open Channel Flow Meter
Diversion Vault	
Structure	72-inch Precast Concrete Manhole
Inlet	21-inch PVC (south)
Outlet	21-inch PVC (north) 21-inch PVC (east)
Valves	(2) Slide gate

City personnel indicate the outfall sewer is in good condition. No recent leaks, main breaks or issues related to the condition of the manholes has been reported.

Circular DEQ-2 specifies sewer conveyance infrastructure including gravity sewers must be sized to carry the peak hour flow. As previously mentioned, the outfall sewer is a 21-inch PVC sewer main. According to the record drawings, the minimum slope along the pipe line is 0.10%. Calculations, provided in Appendix 3, indicate the capacity when the pipe is 75% full is about 2,050 gpm or 2.95 MGD. When the pipe is full the calculated capacity is 2,250 gpm (3.24 MGD). The current peak hour flow is 2.36 MGD, so the pipe is not yet at capacity. Approximately 19% of the outfall sewer has a slope greater than 0.10%.

3.2.4 East Interceptor Sewer

A 21-inch sewer interceptor was constructed around ten years ago on the east side of Belgrade. Documentation related to the SID #79 improvements indicates the interceptor was intended to "serve all new developments on the southeast side of Belgrade and areas south of I-90". The interceptor is a 21-inch sewer main located on the east side of Belgrade. Figure 3-1 indicates the location of the interceptor.

The slope of the interceptor is not known; however, the capacity can be estimated using Circular DEQ-2's minimum slope for 21-inch sewer mains: 0.10%. The capacity of the east interceptor when flowing 75% full is about 2,050 gpm and when flowing full is 2,250 gpm. Calculations are provided in Appendix 3. The maximum theoretical capacity of the pipe, when flowing about 94% full, is 2,419 gpm.

3.2.5 Interstate 90 Crossing

The sewer system south of Interstate 90 is conveyed through two parallel gravity mains under the interstate. The parallel mains begin at a manhole in Alaska Frontage Road, south of the

interstate, and end at a manhole at the intersection of Stiles Avenue and Colorado Street. According to 1995 MDT plans, the crossing includes two 12-inch PVC SDR 35 gravity mains which slope at 0.444%. The capacity of the crossing when the pipes are 75% full is 1,850 gpm and when the pipes are flowing full the capacity is 2,030 gpm. The 1995 plan sheet and capacity calculation are provided in Appendix 3.

3.2.6 RV Dump Stations

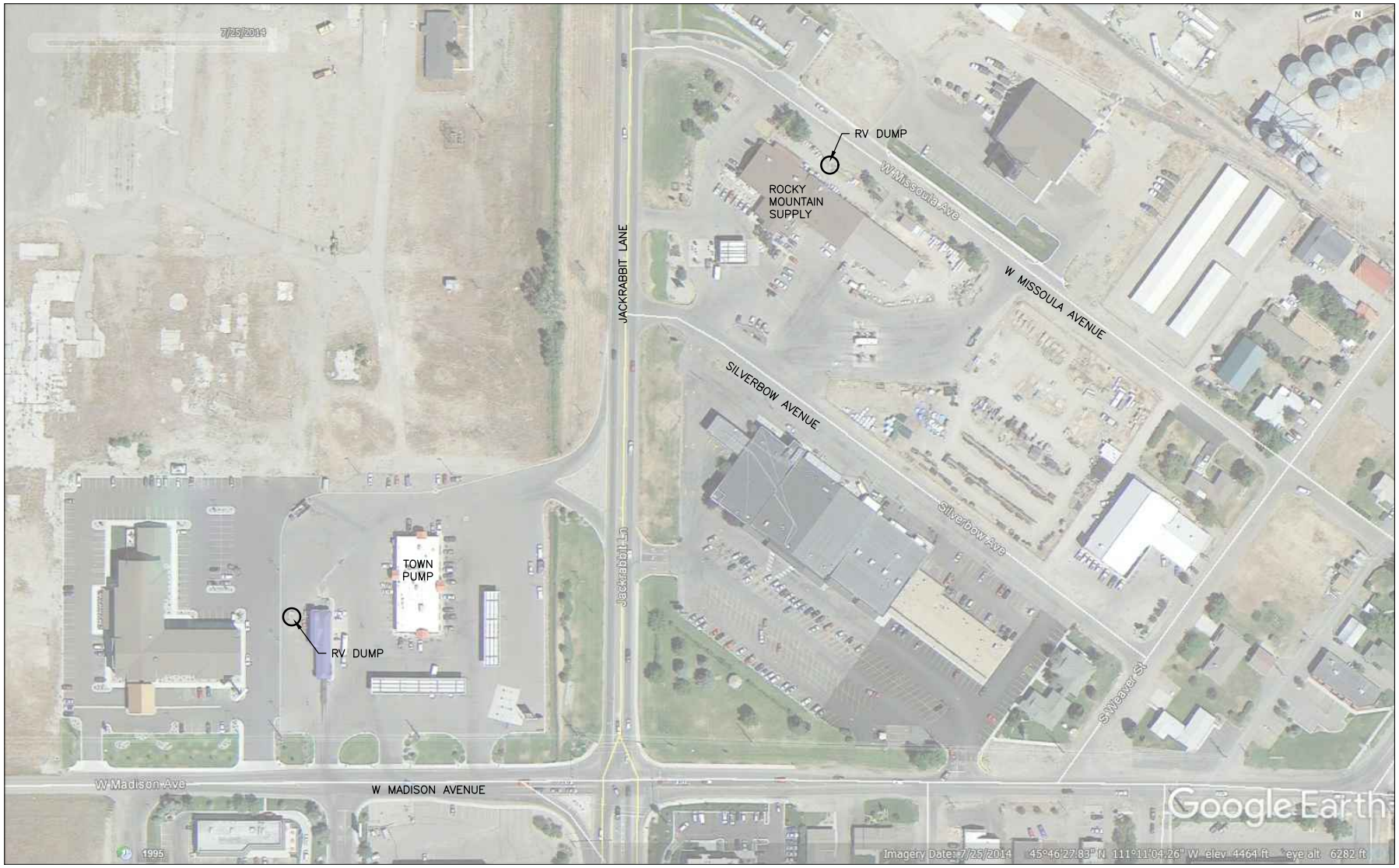
There are two RV dumps in the City of Belgrade; both contribute flow to the WWTP. They are located at two service stations on Jackrabbit Lane north of Interstate 90: Town Pump and Rocky Mountain Supply. Photos of the facilities are provided in Appendix 3 and their locations are indicated in Figure 3-2.

The RV dump at Rocky Mountain Supply flows through gravity mains to the sewer vault in Dry Creek Road. The second RV dump station at Town Pump flows to the Jackrabbit Lift Station. City personnel indicate they recently forced a closure of the Town Pump facility due to lift station pump damage. The pumps were replaced in 2012 because of a flexible hose left at the RV dump station entering the sewer system. Town Pump and City personnel have attempted to prevent hoses entering the City system by installing screws inside the drop pipe; however, the screws have been removed multiple times by patrons whose RV hoses would not stay in the drop pipe.

It is recommended to modify the Town Pump RV dump station to prevent tampering with the drop pipe and to prevent hoses from impacting the downstream lift station. Solutions may include one or more of the following:

- Place the trash rack at the Jackrabbit Lift Station into service to catch any hoses or other debris from the dump station;
- Modify the bollards at the dump station so vehicles can park closer to the drop pipe;
- Raise the drop pipe a few inches and reinstall screws to provide more depth for RV drain pipes to “grip”;
- Add a p-trap and sewer cleanout to catch hoses or debris before it reaches the lift station;
- Replace the screws in the drop pipe with an anchored steel rod and remove and replace a section of the concrete pad.
- Install a sewer manhole with a trash rack downstream of the RV dump.

It is recommended the City adopt design standards for RV dump stations to prevent similar issues at future installations.



NO SCALE

NOT FOR CONSTRUCTION

BELGRADE SEWER MASTER PLAN
BELGRADE, MONTANA

RV DUMP LOCATIONS

TD&H Engineering
406.761.3010 • tdhengineering.com
1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY:	CEVJ
DESIGNED BY:	
QUALITY CHECK:	
DATE:	2017-05-09
JOB NO.	B16-048
CAD NO.	FIG 3-X RV DUMPS

FIGURE
3-2

3.3 LIFT STATION #1: JACKRABBIT

Lift Station #1, also referred to as Jackrabbit Lift Station, is located east of the intersection of 8th Street and Jackrabbit Lane near Saddle Peak Elementary School. The lift station is in a locked, fenced area. It was moved to its current location in 1978 and at the time of the 1998 *Facilities Plan,* it consisted of a steel tank and concrete wet well with submersible pumps. The *Facilities Plan* recommended multiple repairs and improvements. The station currently consists of a circular concrete wet well and circular concrete valve vault with duplex submersible pumps. In 2012 the pumps were replaced and a bypass connection was installed. The current submersible pumps are Flygt model NP3153 with 20 hp motors and a duty point of 535 gpm at 80 ft total dynamic head (TDH). The station includes a trash rack; however, it is not used. A dedicated automatic transfer switch (ATS) at the station provides access to backup power from the elementary school's emergency generator. Figure 3-3 presents the location and layout of the lift station. Photos and notes from a site visit are provided in Appendix 3.

Jackrabbit Lift Station serves a large area of central Belgrade. Prior to September 2013, Lift Station #2 (Cruiser) contributed flow directly to Jackrabbit. An evaluation of the Cruiser and Jackrabbit lift stations was completed by Morrison Maierle, Inc. in 2013. The report, *Lift Station #2 Force Main Improvements,* indicated the Jackrabbit Lift Station was nearing capacity and proposed to reroute the Cruiser Lift Station directly to the sewer vault on Dry Creek Road.

Lift Station #1 discharges to a 6-inch force main which terminates in a manhole near the intersection of Al Drive and Amsterdam Boulevard. A 10-inch gravity main then conveys the flow to the sewer vault on Dry Creek Road.

The City of Belgrade's SCADA system continuously receives alarms and pump run times from the Jackrabbit Lift Station. At this time, wet well depths and lift station flow rates are not measured or reported. The station is controlled with a pressure transducer in the wet well. Alarms are communicated through the SCADA system and radio telemetry to City personnel. The system continuously records RTU (remote telemetry unit) temperature and battery voltage.

CONTROL AND ELECTRICAL PANELS

VALVE VAULT

WET WELL

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

LIFT STATION #1: JACKRABBIT

TD&H Engineering
406.761.3010 • tdhengineering.com
1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY:	CJS
DESIGNED BY:	CEVJ
QUALITY CHECK:	
DATE:	04/28/2017
JOB NO.	B16-048
CAD NO.	FIG 3-X LIFT STATIONS

FIGURE
3-3

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 3-X LIFT STATIONS.dwg, 4/28/2017 3:33:55 PM, cjs

3.3.1 Capacity

Lift station capacity is largely dependent on the capacity of the pumps and the inflow rate to the wet well. Pump run times are also indicators of lift station performance. Multiple data sources were analyzed including a draw down test, SCADA data, and electricity usage records. Calculations are provided in Appendix 3 and copies of the SCADA data are available electronically.

3.3.1.1 Pump Capacity

A draw down test was completed by TD&H Engineering on April 13, 2017 at 9:30 am. Assuming a constant inflow to the wet well during the testing period, results indicate Pump #1 provided 543 gpm and Pump #2 provided 527 gpm. The capacity of the station should be taken as the lowest available pumping rate, or 527 gpm.

3.3.1.2 Pump Run Times and Contributing Flow Rates

Daily pump run times are reported by the SCADA system and inflow rates were estimated from the station's SCADA event log by dividing the active wet well volume by the time increments when no pumps were in operation. Pump run times were evaluated from 2010 to 2016 and inflow rates were estimated using 2015 and 2016 data. Chart 3-2 presents the average pump run time from 2010 to 2016. The station run time is equal to the sum of the individual pump run times.

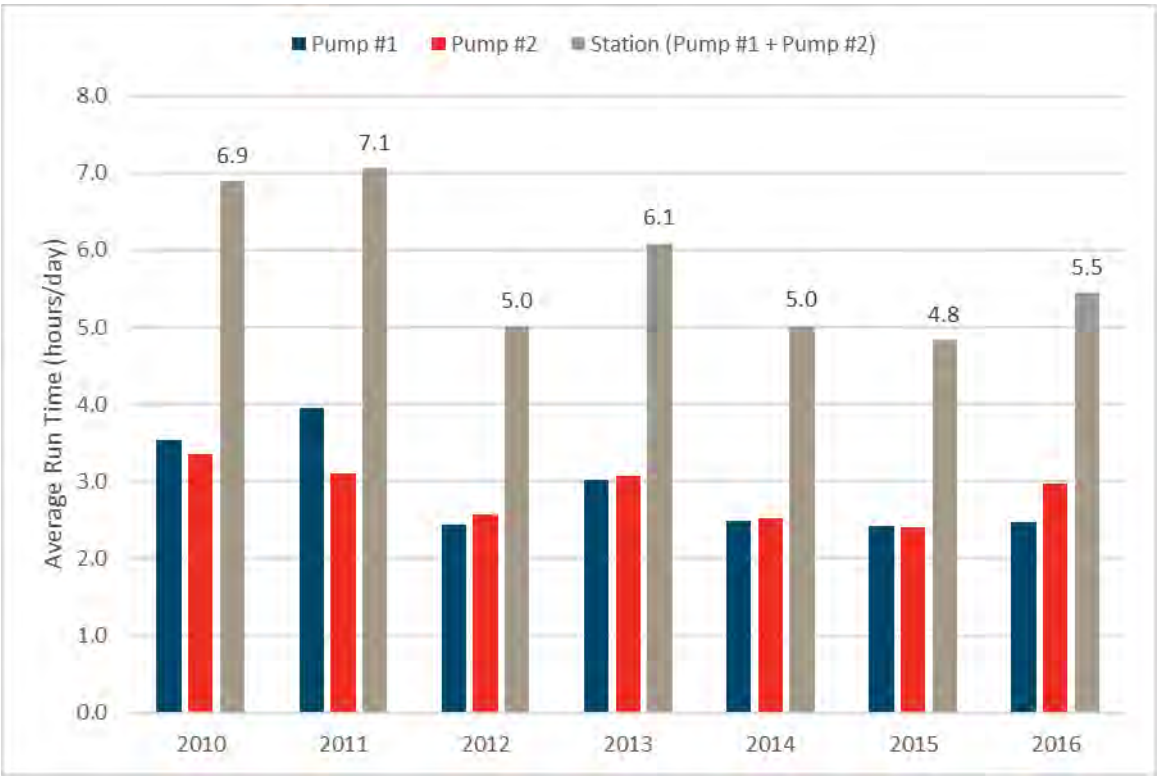


Chart 3-2. Jackrabbit Lift Station Average Daily Pump Run Time

Pump run times decreased in 2014 after the Cruiser Lift Station was rerouted to the sewer vault on Dry Creek Road. The average total run time was 6.3 hours per day from 2010 to 2013; from 2014 to 2016, the average run time decreased to 5.1 hours per day.

The SCADA event log analysis indicates minimal seasonal variations in the average wet well inflow rate. The average inflow rate during 2015 and 2016 was 189 gpm, the peak hourly inflow was 503 gpm (April 2015), and the peak instantaneous flow was 564 gpm on January 22, 2015.

3.3.1.3 Electricity Usage and Pump Run Times

Electrical demand and usage at the Jackrabbit lift station was provided by the City for January 2013 to September 2016. The records report monthly energy usage in kWh and power demand in kW. By dividing the energy usage by the demand, the pumping hours can be estimated. Table 3-6 presents the energy usage, demand, and pump run times predicted at the Jackrabbit Lift Station.

Table 3-6
Jackrabbit Lift Station Power Usage

Year	Total Energy Used	Average Energy Demand	Annual Pump Run Time[1]	Average Daily Pump Run Time
2013	33,435 kWh	14.8 kW	3,535.3 hrs	9.7 hrs/day
2014	26,903 kWh	10.1 kW	3,161.2 hrs	8.7 hrs/day
2015	25,743 kWh	7.1 kW	3,728.4 hrs	10.2 hrs/day
2016[2]	21,433 kWh	8.6 kW	2,711.2 hrs	9.9 hrs/day
Average	***26,879 kWh***	***10.1 kW***	***3,284.0 hrs***	***9.6 hrs/day***

[1]Calculated using the monthly energy usage and demand.
[2]January to September.

The power usage analysis estimates a pump run time of 9.6 hours per day which differs significantly from the SCADA pump run time data. The source of the discrepancy is not known; however, it is likely caused by power draw from other equipment at the site and from the startup draw of the pumps. The pump run time calculated by the SCADA data is most representative of the hydraulic behavior of the station.

3.3.1.4 Capacity Summary and Conclusions

The various field tests and calculations indicate the following:

- Lift station pumping capacity:
  - Original = 535 gpm
  - Current = 527 gpm
- Average day inflow = 189 gpm
- Peak hour inflow = 503 gpm
- Peak instantaneous inflow = 564 gpm
- Average pump run time:
  - Historical = 6.3 hours per day
  - Current = 5.1 hours per day

Circular DEQ-2 states that the lift station pumping capacity must be equal to or greater than the peak hour design flow. The peak hour flow measured in 2015 and 2016 was less than the current pumping capacity; therefore, the station is not at full capacity.

The remaining capacity of the station can be approximated by assuming, in accordance with Circular DEQ-2, that the peak hour flow to the station should not exceed the pumping capacity. Therefore, the remaining peak hour capacity of the Jackrabbit Lift Station is approximately:

527 gpm – 503 gpm = **24 gpm**.

It is recommended that additional connections to the Jackrabbit service basin not increase the peak hour flow above the pumping capacity; however, it is acknowledged that occasional peak instantaneous flows may occur which exceed the capacity of the station. It is also not unusual for an existing station to continue operating under conditions where the peak hour flow is intermittently exceeded. If a more detailed analysis of the pumping capacity is required, then it is recommended to add continuous depth and flow measurement capabilities to the station.

3.3.2 Condition and Deficiencies

TD&H Engineering conducted a site visit to the Jackrabbit lift station on October 20, 2016 to document the station's condition by visual observation of the components, verbal reports from City personnel, and field data. Table 3-7 presents a summary of the main components in the station, their condition, and recommended improvements. The operator's logs are summarized in Appendix 3 and list the date of repairs and control panel errors.

Table 3-7 Jackrabbit Lift Station Equipment Condition and Recommendation Summary		
Component	**General Condition**	**Recommendation**
West Submersible Pump	Replaced in 2012	OK
West Pump Motor	Replaced in 2012	OK
East Submersible Pump	Replaced in 2012	OK
East Pump Motor	Replaced in 2012	OK
Wet Well Structure	Concrete; good condition; inverted "j" tube vent present	OK
Wet Well Piping and Fittings	Some visible corrosion, but not severe.	OK
Pressure Transducer	Continual issues with detachment and failure due to placement in wet well.	Replace and adjust location to minimize damage from turbulence and/or install stilling tube, and/or modify influent pipe with deflector panel/drop pipe.
Pump Lift Rails	Some surface corrosion visible, yet still functional.	OK
Valve Vault	Concrete, good condition with floor drain. Standing water was visible on floor during site visit.	Clean floor drain to eliminate standing water.
Check valves	Adequate condition	OK
Plug valves	Adequate condition	OK
Emergency Bypass Piping	Present	OK
Controls	External housing, functional, radio telemetry	OK; if pump panels can calculate pumping rate, then enable this feature and send data to SCADA
Alarms	The following alarms are available: pump 1 failure, pump 2 failure, entry alarm, power, and lift station level. DEQ requires both high and low-level alarms and the SCADA description does not indicate which is provided.	Add level alarms in accordance with DEQ requirements
Electrical	External housing, functional, dedicated ATS for shared genset.	OK

In general, the condition of the station is adequate. It appears that most of the mechanical and structural components were replaced recently. The operator logs indicate a history of probe errors. In one instance, a probe error caused one of the pumps to run for over 15 hours. The floor drain in the valve vault may also be obstructed since standing water was observed during the site visit. It is recommended to install a new level measurement device and to investigate

the addition of a stilling well or deflector panel at the influent pipe. Level alarms should be modified to comply with Circular DEQ-2 requirements.

3.3.3 Force Main

A 6-inch force main conveys flows from the lift station to a manhole in Al Drive. The pipe material is unknown. Applying the pumping rates calculated in the draw down test, the force main velocity is 6.0 ft/sec to 6.2 ft/sec. A calculation is provided in Appendix 3. Circular DEQ-2 requires a minimum cleaning velocity of 2 ft/sec and a maximum velocity of 8 ft/sec; Lift Station #1 meets the velocity requirements.

3.4 LIFT STATION #2: CRUISER

Lift Station #2, located on the southeast corner of the intersection of Cruiser Lane and Jackrabbit Lane, is a submersible duplex lift station with a rectangular wet well and an underground valve vault. It was installed in the early 2000's. The lift station is surrounded by a chain link fence with three-strand barbed wire. The controls and electrical panels are housed in external enclosures inside the gate. A backup generator is not present at the station. Figure 3-4 presents the location and layout of the lift station. Photos and notes from a site visit are provided in Appendix 3.

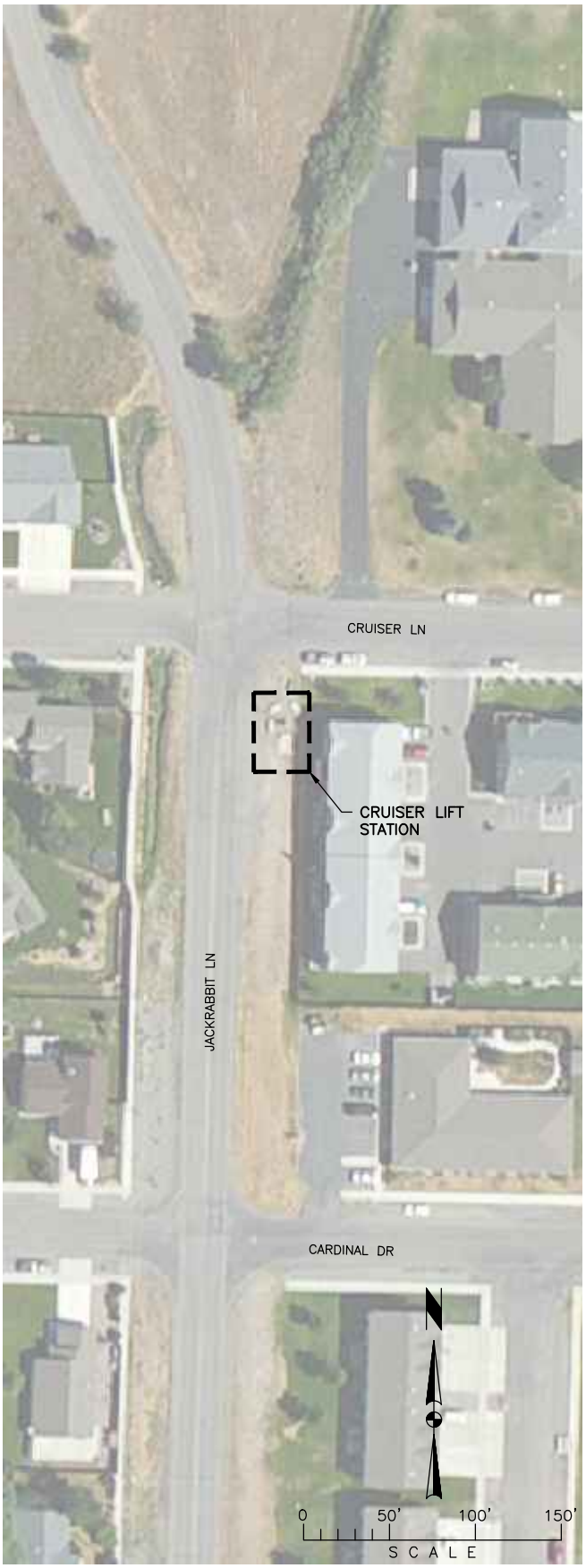
The lift station receives wastewater from a largely residential area in north Belgrade. Originally, the Cruiser lift station discharged to Lift Station #1 through a 10-inch force main in Jackrabbit Lane. The 2013 report, *Lift Station #2 Force Main Improvements,* recommended discharging flows from Cruiser Lift Station directly to the sewer vault in Dry Creek Road. Based on the recommendations, in 2013 the Cruiser Lift Station was rerouted through a 10-inch force main to the sewer vault. The existing 72-inch circular vault, piping, and valves were demolished and replaced. The existing 4-inch submersible pump discharge piping was increased to 6-inch inside the vault and new check and plug valves were installed on each pump discharge line. The new vault also included a bypass pumping connection to permit emergency bypassing of the lift station's submersible pumps.

The City of Belgrade's (SCADA system continuously receives alarms and pump run times from the Cruiser Lift Station. Alarms from the station are communicated to City personnel via radio telemetry. At this time, wet well depths and lift station flow rates are not measured or reported. The station is controlled with several floats in the wet well, so no inputs are available for continuous measurement. RTU temperature and battery voltage are reported continuously. The submersible pumps and 10 HP motors are original to the station. According to the 2013 report *Lift Station #2 Force Main Improvements,* the pumps were sized for 395 gpm at 48.5 ft total dynamic head (TDH).

VALVE VAULT

WET WELL

SITE



BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

LIFT STATION #2: CRUISER

TD&H Engineering
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1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY:	CJS
DESIGNED BY:	CEVJ
QUALITY CHECK:	
DATE:	04/28/2017
JOB NO.	B16-048
CAD NO.	FIG 3-X LIFT STATIONS

FIGURE
3-4

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 3-X LIFT STATIONS.dwg, 4/28/2017 3:34:07 PM, cjs

3.4.1 Capacity

The capacity of the existing lift station is largely dependent on the capacity of the pumps and the inflow rate to the wet well. Pump run times are also indicators of lift station performance. Multiple data sources were analyzed including a draw down test, SCADA data, and electricity usage records. Calculations are provided in Appendix 3 and copies of the SCADA data are available electronically.

3.4.1.1 Pump Capacity

A draw down test was completed by TD&H Engineering on November 16, 2016 between 10 am and 11 am. Assuming a constant inflow to the wet well during the testing period, results indicate the east pump provided 290 gpm and the west pump provided 357 gpm. The capacity of the station should be taken as the lowest available pumping rate, or 290 gpm.

3.4.1.2 Pump Run Times and Contributing Flow Rates

Daily pump run times are reported directly by the SCADA system and inflow rates were estimated from the station's SCADA event log by dividing the active wet well volume by the time increments when no pumps were in operation. Pump run times were evaluated from 2010 to 2016 and inflow rates were estimated using 2015 and 2016 data. Chart 3-3 presents the average pump run time from 2010 to 2016. The station run time is equal to the sum of the individual pump run times.

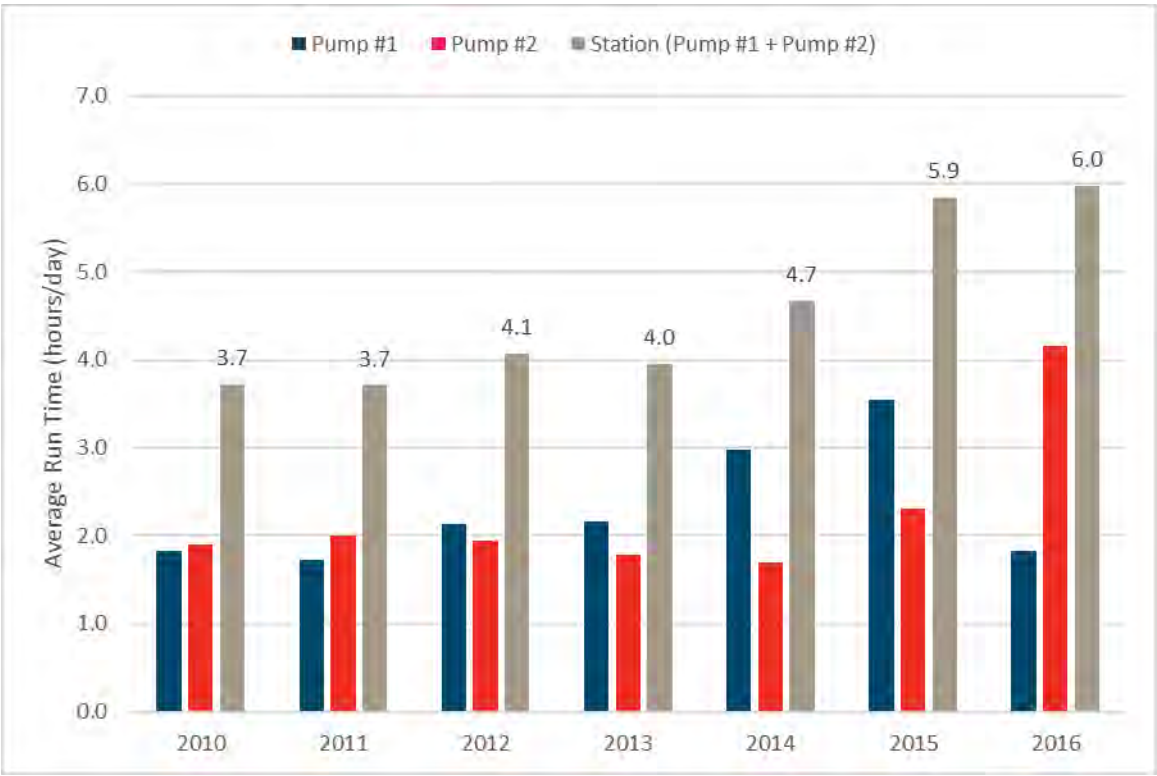


Chart 3-3. Cruiser Lift Station Average Daily Pump Run Time

Pump run times have increased since 2014. The average total run time before 2014 was 3.9 hours per day. In 2016, the average total run time increased to 6.0 hours per day. The increase may be related to mechanical issues with the pumps, discussed the following sections.

The SCADA event log data analysis indicates there are seasonal variations in the hourly inflow rate to the lift station. The highest flows occur in mid-summer and early autumn. The average inflow rate from January 2015 to December 2016 was 87 gpm. The peak hour flow to Cruiser Lift Station ranged from 119 gpm in February 2016 to 584 gpm in August 2015. The peak instantaneous flow occurred on August 22, 2015 and was approximately 621 gpm.

3.4.1.3 Electricity Usage and Pump Run Times

Electrical demand and usage at the Cruiser lift station was provided by the City for January 2013 to September 2016. The records report monthly energy usage in kWh and power demand in kW. By dividing the energy usage by the demand, the pumping hours can be estimated. Table 3-8 presents the energy usage, demand, and pump run times predicted at the Cruiser lift station.

Table 3-8
Cruiser Lift Station Power Usage

Year	Total Energy Used	Average Energy Demand	Annual Pump Run Time[(1)]	Average Daily Pump Run Time
2013	14,682 kWh	10.9 kW	1,443.8 hrs	4.0 hrs/day
2014	17,921 kWh	9.3 kW	2,063.4 hrs	5.7 hrs/day
2015	22,053 kWh	9.6 kW	2,312.9 hrs	6.3 hrs/day
2016[(2)]	15,354 kWh	9.0 kW	1,743.7 hrs	6.4 hrs/day
Average	***17,503 kWh***	***9.7 kW***	***1,891.0 hrs***	***5.6 hrs/day***

[(1)]Calculated using the monthly energy usage and demand.
[(2)]January to September.

The power usage analysis predicts an average energy demand of 9.7 kW and an estimated pump run time of 5.6 hours per day. It is not unexpected that the daily pump run time is greater according to the electrical data because the meter is recording all electrical activity at the lift station including the controls and the initial pump motor power draw.
|

3.4.1.4 Capacity Summary and Conclusions

The various field tests and calculations indicate the following:

- Lift station pumping capacity:
  - Original = 395 gpm
  - Current = 290 gpm
- Average inflow = 87 gpm
- Peak hour inflow = 584 gpm
- Peak instantaneous inflow = 621 gpm
- Average pump run time:
  - Historical = 3.9 hours per day
  - Current = 5.9 hours per day

Circular DEQ-2 states that the lift station must convey the peak hour flow. Over time, the capacity of the pumps has decreased with one pump only capable of 73% of the original design capacity. The SCADA data indicates peak hour flows to the lift station are higher than the current pumping capacity; therefore, it is not recommended to allow additional developments to contribute flow to the Cruiser Lift Station. While the peak hour flows do exceed the pumping capacity, the pump run times are not excessive. The station appears to have adequate capacity during average demand conditions; emergency improvements to increase the lift station capacity are, therefore, unnecessary.

3.4.2 Condition and Deficiencies

TD&H Engineering conducted a site visit to the Cruiser lift station on October 20, 2016 to document the station's condition by visual observation of the components, verbal reports from City personnel, and field data. Table 3-9 presents a summary of the main components in the station, their condition, and recommended improvements. The operator's logs are summarized in Appendix 3 and list the date of repairs and control panel errors.

Table 3-9 Cruiser Lift Station Equipment Condition and Recommendation Summary		
Component	**General Condition**	**Recommendation**
West Submersible Pump	Near end of useful life, reduced capacity	Replace and increase capacity
West Pump Motor	Continual issues with seal failures	Replace
East Submersible Pump	Pump doesn't seat properly, near end of useful life, significantly reduced capacity	Replace and increase capacity
East Pump Motor	Continual issues with seal failures	Replace
Wet well structure	Concrete; good condition; inverted “j” tube vent present	OK
Wet Well Piping and Fittings	Some visible corrosion	Replace
Floats	Older equipment, but functional; does not provide depth signal to SCADA system	Replace and/or add level transducer for depth and flow measurements to SCADA system
Pump Lift Rails	Steel I-beams, warped	Replace
Valve Vault	Replaced in 2013; however, no floor drain is visible in as-builts or photos	Install a floor drain in the vault which drains to the wet well to comply with DEQ-2
Check valves	Replaced in 2013	OK
Plug valves	Replaced in 2013	OK
Emergency Bypass Piping	Added in 2013	OK
Controls	External housing, functional, older equipment, radio telemetry	Replace
Alarms	The following alarms are available: pump 1 failure, pump 2 failure, entry alarm, power, and lift station level. DEQ requires both high and low-level alarms and the SCADA description does not indicate which is provided.	Add level alarms in accordance with DEQ requirements
Electrical	External housing, functional, older equipment, no backup power	Replace and update all electrical; add backup generator to comply with DEQ-2

In general, the condition of the wet well and valve vault are adequate; however, the pumps are in poor condition and there is no backup power to the station. The operator logs indicate continual issues with the pump seals and the draw down test indicates the capacity of one pump has been greatly decreased. Repair or replacement of the lift station is recommended to provide adequate and reliable pumping capacity at the Cruiser Lift Station.

3.4.3 Force Main

The velocity in the 10-inch force main was analyzed to determine if the minimum cleaning velocity of 2 ft/sec is provided. The 2013 lift station improvement project indicates the new 10-inch force main is DR18 C900 PVC with an inside diameter of 9.79-inches. A data sheet, provided in Appendix 3, provides the typical dimension of the referenced pipe material. The draw down test indicates the lift station pumps at a rate of 357 gpm (0.80 cfs) or 290 gpm (0.65 cfs). Referencing the continuity equation, the resulting force main velocity ranges from 1.2 to 1.5 ft/sec, less than the DEQ-required 2 ft/sec. Presumably, the force main was oversized for future development.

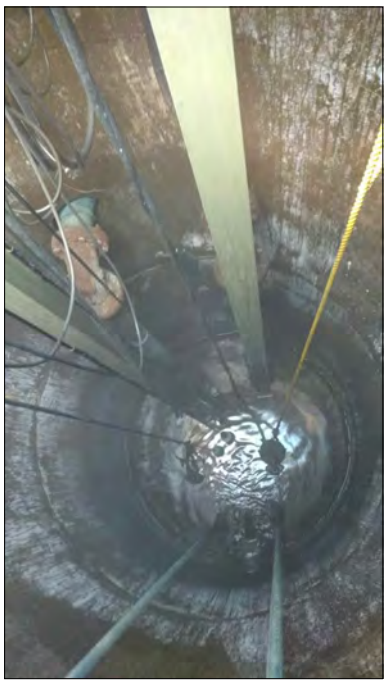
3.5 LIFT STATION #3: GALLATIN FARMERS

Lift Station #3 is located on Gallatin Farmers Avenue near the intersection with West Northern Pacific Avenue; it is between the Montana Rail Link railroad and Interstate 90. The site is commonly referred to as the “Farmers”, “Gallatin Farmers”, or “Pacific” Lift Station. It was built in 1999 and serves one block of commercial and industrial properties on Gallatin Farmers Avenue. Figure 3-5 presents the location and layout of the lift station. Photos and notes from a site visit are provided in Appendix 3.

The submersible duplex station includes a wet well and buried valve vault; both are circular concrete structures. There is a bypass piping connection in the valve vault and a drain. The site is unfenced with no backup power. The original capacity of the submersible Hydromatic pumps is not known; the as-built drawings do not list any of the pump or motor characteristics. A 4-inch force main conveys the flows to a manhole in West Northern Pacific Avenue.

The City of Belgrade’s SCADA system continuously receives alarms and pump run times from the Gallatin Farmers Lift Station. Alarms from the station are communicated to City personnel via radio telemetry. At this time, wet well depths and lift station flow rates are not measured or reported. The station is controlled with several floats in the wet well, so no inputs are available for continuous measurement. RTU temperature and battery voltage are measured and reported continuously.

VALVE VAULT



WET WELL

SITE

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BELGRADE, MONTANA

LIFT STATION #3: GALLATIN FARMERS

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DRAWN BY:	CJS
DESIGNED BY:	CEVJ
QUALITY CHECK:	
DATE:	04/28/2017
JOB NO.	B16-048
CAD NO.	FIG 3-X LIFT STATIONS

FIGURE

3-5

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 3-X LIFT STATIONS.dwg, 4/28/2017 3:34:20 PM, cjs

3.5.1 Capacity

The capacity of the existing lift station is dependent on the capacity of the pumps and the inflow rate to the wet well. Pump run times are also indicators of lift station performance. Multiple data sources were analyzed including a draw down test, SCADA data, and electricity usage records. Calculations are provided in Appendix 3 and copies of the SCADA data are available electronically.

3.5.1.1 Pump Capacity

A draw down test was completed by TD&H Engineering on April 13, 2017 at 9:00 am. Assuming a constant inflow to the wet well during the testing period, results indicate Pump #1 provided 141 gpm and Pump #2 provided 212 gpm. The capacity of the station should be taken as the lowest available pumping rate, or 141 gpm.

3.5.1.2 Pump Run Times and Contributing Flow Rates

Daily pump run times are reported by the SCADA system and inflow rates were estimated from the station's SCADA event log by dividing the active wet well volume by the time increments when no pumps were in operation. Pump run times were evaluated from 2010 to 2016 and inflow rates were estimated using 2015 and 2016 data. Chart 3-4 presents the average pump run time from 2010 to 2016. The station run time is equal to the sum of the individual pump run times.

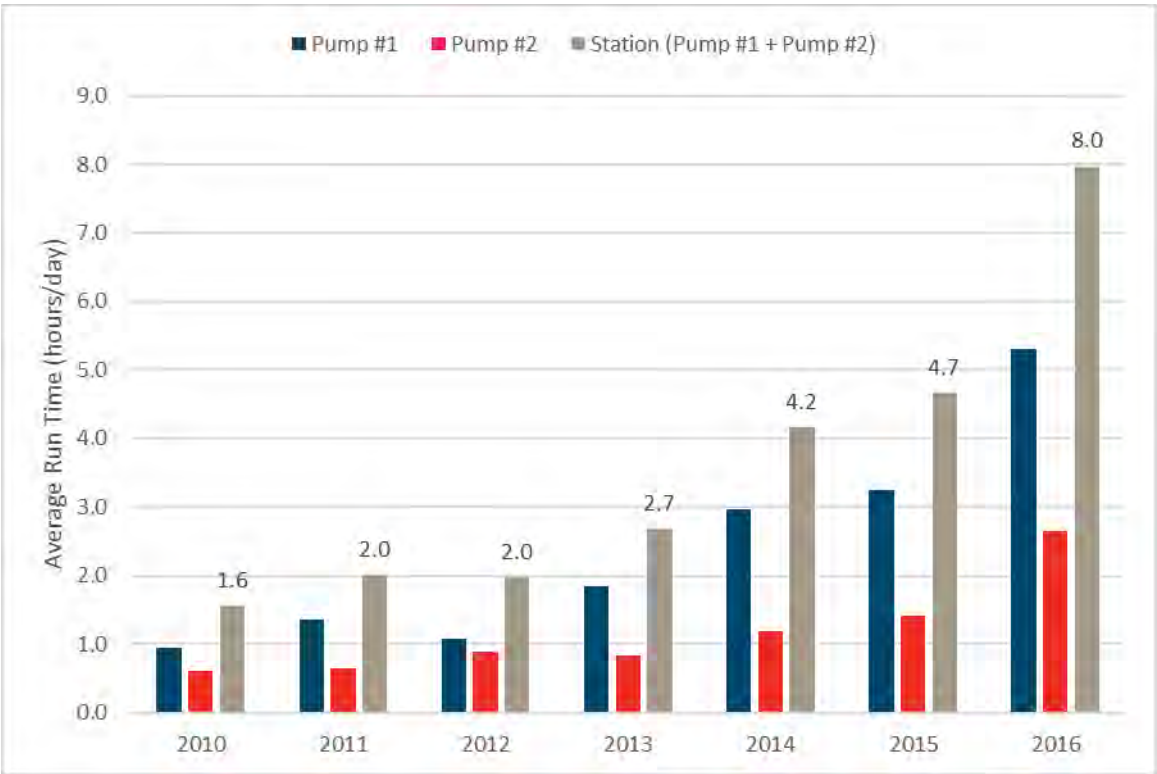

Chart 3-4. Gallatin Farmers Lift Station Average Daily Pump Run Time

Overall station run time has steadily increased from 2012 to 2016. In 2016 the average station run time was 8 hours per day compared to 2 hours per day in 2011 and 2012.

The station serves a small number of businesses on Gallatin Farmers Avenue. There are a few empty lots on the street, so recent development may have contributed to the increased operation; however, the degree to which the pump run times increased is not commensurate with the number of lots available. Maintenance issues, discussed below, are the likely cause of the increase.

The SCADA event log analysis indicates that the lift station primarily operates during the day Monday through Friday and that inflows are not strongly influenced by seasonal variations. Several charts are provided in Appendix 3 which depict the average hourly and daily inflow rates during 2016 and illustrate that wastewater demands primarily occur during business hours. The estimated average hourly inflow during 2015 and 2016 was 17 gpm. The peak hour flow varied from 44 gpm to 138 gpm. The peak instantaneous flow was also 138 gpm and occurred between 8 and 9 am on February 10, 2016. The analysis estimates the same peak hour and peak instantaneous flows during the analysis period because the pumps run infrequently and there was only one inflow measurement between 8 am and 9 am on February 10th.

3.5.1.3 Electricity Usage and Pump Run Times

Electrical usage, in kWh, was provided for the Gallatin Farmers Lift Station by the City for January 2013 to September 2016. Power demand at the meter, measured in kW, was not available in the records, so pumping hours cannot be estimated. Table 3-10 presents the total energy usage at the Gallatin Farmers Lift Station.

Table 3-10
Gallatin Farmers Lift Station Power Usage

Year	Total Energy Used
2013	2,308 kWh
2014	2,713 kWh
2015	3,540 kWh
2016(2)	4,153 kWh
Average	***3,179 kWh***

(1)Calculated using the monthly energy usage and demand.
(2)January to September.

3.5.1.4 Capacity Summary and Conclusions

The various field tests and calculations indicate the following:

- Lift station pumping capacity:
  - Current = 141 gpm
- Average day inflow = 17 gpm
- Peak hour inflow = 138 gpm
- Peak instantaneous inflow = 138 gpm
- Average pump run time:
  - Historical = 2.0 to 4.2 hours per day
  - Current = 8.0 hours per day

No documentation is available which defines the design capacity of the Farmers Lift Station. The draw down test indicates the pumps were originally capable of at least 212

gpm; however, over time the capacity of one of the pumps decreased to only 141 gpm. Circular DEQ-2 states that the lift station must convey the peak hour design flow. The peak hour flow estimated using the SCADA event log data is slightly less than the station's pumping capacity; therefore, the station should be considered near capacity. If additional sewer connections are proposed in the service area, it is recommended to replace at least the lower capacity pump to a rate at or above the original design capacity. If the original design conditions cannot be discovered in the City's records, then an updated design capacity evaluation should be completed.

3.5.2 Condition and Deficiencies

TD&H Engineering conducted a site visit to the Farmers Lift Station on October 20, 2016 to document the station's condition by visual observation of the components, verbal reports from City personnel, and field data. Table 3-11 presents a summary of the main components in the station, their condition, and recommended improvements. The operator's logs are summarized in Appendix 3 and list the date of repairs and control panel errors.

During 2016 the condition of the lift station deteriorated; the operator logs indicate at least half a dozen occasions when one of the pumps was found to be running for excessive periods of time. For example, the east pump ran for 17.8 hours on July 13th and three days later it ran for 14 hours. The station also has long term maintenance issues with debris and dye clogging the check valves and depositing in the wet well. The effects, if any, of the dye which has been observed by City personnel in the wet well and valve vault should be investigated further. It may be necessary to research the composition of the dye and determine if it can negatively impact the lift station components. If the dye if found to detrimentally affect the mechanical equipment or instrumentation, pretreatment at the source may be necessary.

Table 3-11 Gallatin Farmers Lift Station Equipment Condition and Recommendation Summary		
Component	**General Condition**	**Recommendation**
Submersible Pumps	Near end of useful life; one pump has reduced capacity; excessive run times.	Replace; review capacity.
Pump Motors	Near end of useful life; no issues reported.	Replace
Wet Well Structure	Concrete; good condition; inverted "j" tube vent present; dye builds up in bottom of hopper	OK
Wet Well Piping and Fittings	Some visible corrosion; near end of useful life.	Replace
Floats	Older equipment; does not provide depth signal to SCADA system. Many instances when pumps do not turn on or shut off at the set points.	Replace with level transducer for depth and flow measurements to SCADA system.
Pump Lift Rails	As-constructed plans indicate a Pentair Pultruded Rail System was specified which includes fiberglass I-beams.	OK
Valve Vault	Includes a drain; floor is coated with a blue-green liquid or dye; interior concrete appears to be in good condition.	Find the source of the blue-green liquid by checking for leaks in the piping connections and cleaning the floor drain piping.
Check valves	Continual issues with valve failure; City has removed rubber bands from the valve; they also suspect there may be buildup from dyes used by local businesses.	Replace; consider a trash rack at the wet well inlet. Contact local business owners and request they cease emptying trash in sewer lines or drains. Investigate alternative valve types and configurations.
Plug valves	Plug valves appear to be newer than the rest of the piping in the valve vault. No reported issues from City personnel.	OK
Emergency Bypass Piping	Plain end PVC pipe with cap.	OK – Consider updating the connection with a cam-lok or flanged fitting for easier connections.
Controls	External housing, functional, older equipment, radio telemetry. Many instances when pumps do not turn on or shut off at the set points.	Replace to be compatible with new level transducer.
Alarms	The following alarms are available: pump 1 failure, pump 2 failure, entry alarm, power, and lift station level. DEQ requires both high and low-level alarms and the SCADA description does not indicate which is provided.	Add level alarms in accordance with DEQ requirements
Electrical	External housing, functional, older equipment, no backup power	Replace and update all electrical; add backup generator to comply with DEQ-2

The station is also nearly 20 years old; some of the components are reaching the end of their useful lives. The draw down test indicates the capacity of one pump is significantly less than the other. In addition, the station has no backup power source as required by DEQ. Repair or replacement of the lift station is recommended to provide a reliable lift station which complies with DEQ standards.

3.5.3 Force Main

The velocity in the 4-inch force main was analyzed to determine if the minimum cleaning velocity of 2 ft/sec is provided. The 1999 plans indicate the force main is 4-inch PVC and the draw down test indicates the lift station pumps at a rate of 141 gpm (0.31 cfs) or 212 gpm (0.47 cfs). Referencing the continuity equation, the resulting force main velocity ranges from 3.6 to 5.4 ft/sec, more than the DEQ-required 2 ft/sec.

3.6 LIFT STATION #4: SID #78/TRUCK STOP

Lift Station #4 was constructed as part of Special Improvement District (SID) #78 south of Interstate 90 and is referred to as the "Truck Stop" or "SID #78" lift station. The station is accessed by Amsterdam Road and is located on a 0.057-acre parcel owned by the City of Belgrade. The duplex submersible station includes a generator building, circular concrete wet well and circular concrete valve vault. Controls and electrical panels are housed in the generator building. The site is not fenced. Wastewater is conveyed through a 6-inch PVC force main that discharges in a manhole approximately 600 feet to the east in Amsterdam Road. Figure 3-6 presents the location and layout of the Truck Stop Lift Station. Photos and notes from a site visit are provided in Appendix 3.

The lift station was completed in 2009 and was designed to serve the SID west of Jackrabbit Lane with provisions for future growth south of Interstate 90. Figure 3-7 presents the boundaries of SID #78 and the planning area. The SID improvements are described in the 2006 report *Design Report for City of Belgrade SID 78 Water & Sewer Improvements.* The report indicates the lift station design flow in SID #78 is 99 gpm and the design flow in the future planning area is 590 gpm. The station was constructed with two submersible pumps sized for 300 gpm at 18.7 ft TDH. If the pumping capacity is increased to 590 gpm at 36.4 ft TDH, the station would convey design flows associated with the future planning area west of Jackrabbit Lane depicted in Figure 3-7.

The City of Belgrade's SCADA system continuously receives alarms and pump run times from the Truck Stop Lift Station. Alarms from the station are communicated to City personnel via radio telemetry. At this time, wet well depths and lift station flow rates are not measured or reported. The station is controlled with a level sensor in the wet well. Three parameters are continuously recorded: wet well level, battery voltage, and RTU temperature. There is a flow rate variable in the SCADA system; however, it has no data.

SITE AND GENERATOR BUILDING

WET WELL

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

LIFT STATION #4: SID #78 / TRUCK STOP

TD&H Engineering
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1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY:	CJS
DESIGNED BY:	CEVJ
QUALITY CHECK:	
DATE:	04/28/2017
JOB NO.	B16-048
CAD NO.	FIG 3-X LIFT STATIONS

FIGURE
3-6

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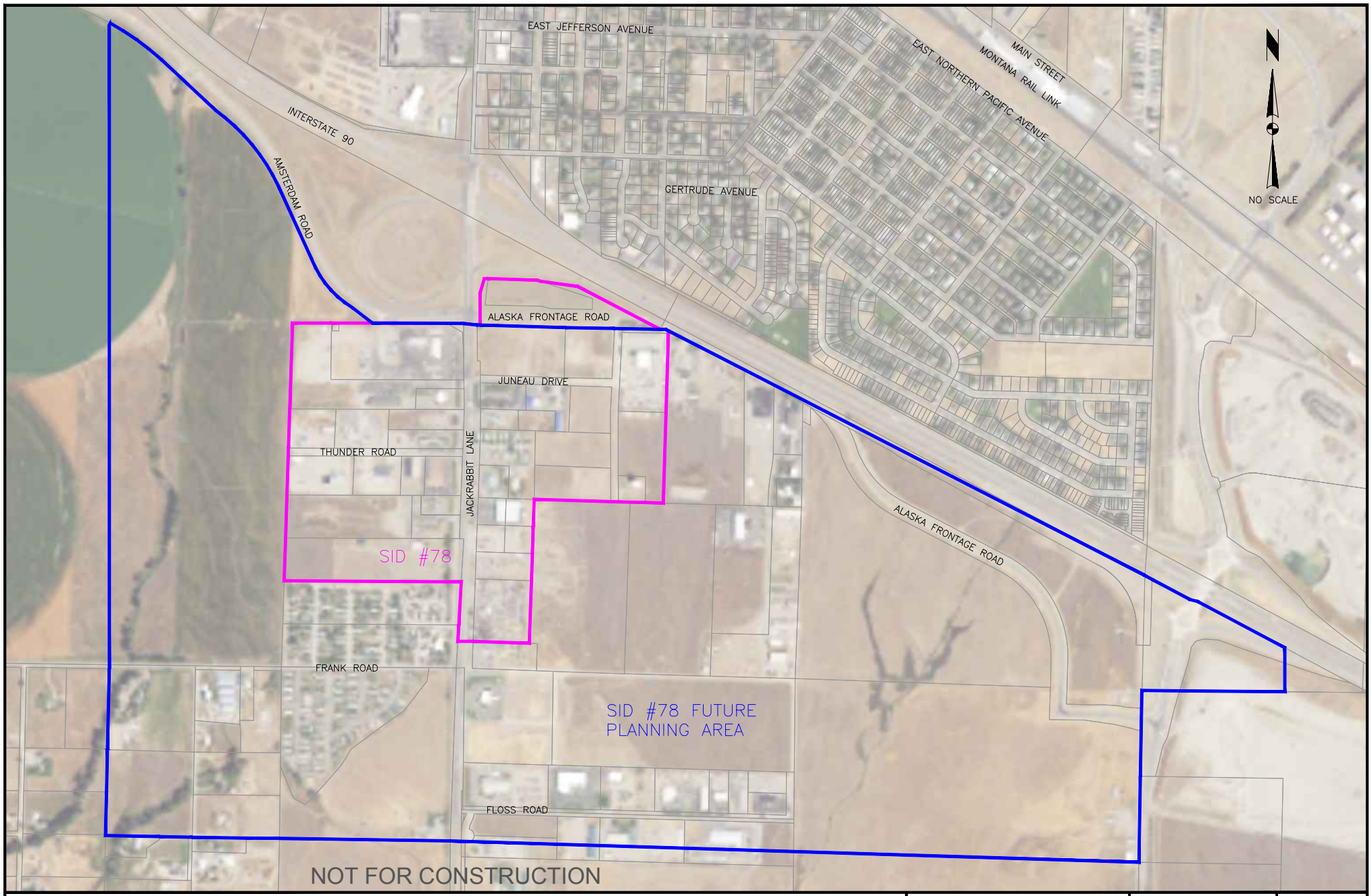

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

SID #78 PLANNING AREA

TD&H Engineering
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1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY:	CEVJ
DESIGNED BY:	
QUALITY CHECK:	
DATE:	2016-05-03
JOB NO.	B16-048
CAD NO.	FIG 3-X SID 78

FIGURE
3-7

3.6.1 Capacity

Typically, a lift station which is only eight years old should not have experienced significant changes in capacity or performance; however, the SID #78 Lift Station has a documented history with probe errors and excessive pump run times. An analysis of the SCADA data and a draw down test were performed to determine whether the design capacity of the station has changed. Multiple data sources were analyzed including a draw down test, SCADA data, and electricity usage records. Calculations are provided in Appendix 3 and copies of the SCADA data are available electronically.

3.6.1.1 Pump Capacity

A draw down test was completed by TD&H Engineering on November 16, 2016. The test consisted of measuring the following: the time to fill the wet well between pumping cycles, the time to draw down the wet well with each pump, and the volume of wastewater between the "on" and "off" float controls. Results of this initial test were inconclusive; the predicted pumping rates were higher than the design capacity of the pumps. Given the station's history of probe errors and issues, the results are not considered indicative of the lift station's performance. A second test, performed by City personnel in December 2017, indicate that each pump is performing near the design capacity: 300 gpm and 291 gpm.

3.6.1.2 Pump Run Times and Contributing Flow Rates

Daily pump run times are reported by the SCADA system and inflow rates were estimated from the station's SCADA event log by dividing the active wet well volume by the time increments when no pumps were in operation. Pump run times were evaluated from 2010 to 2016 and inflow rates were estimated using 2015 and 2016 data. Chart 3-5 presents the average pump run time from 2010 to 2016. The station run time is equal to the sum of the individual pump run times.

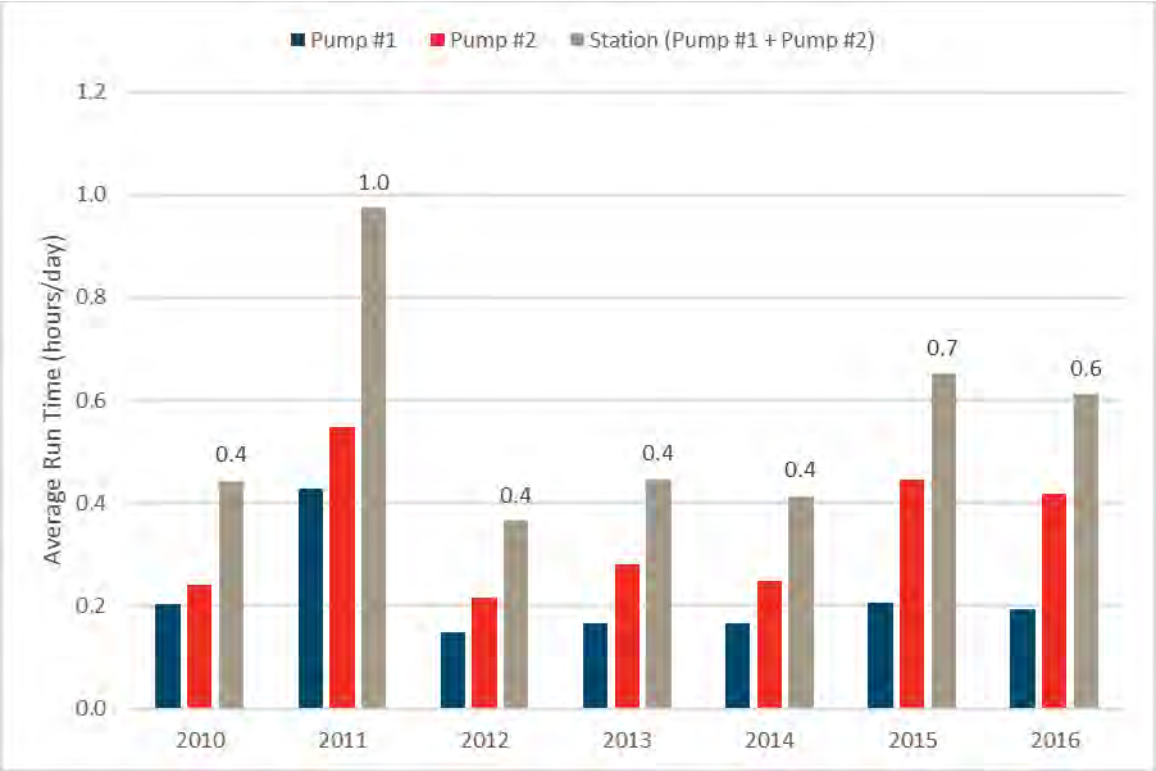


Chart 3-5. SID #78/Truck Stop Lift Station Average Daily Pump Run Time

Pump run time data indicates there was a spike in pump run times during 2011. Average pump operation doubled before decreasing in 2012 to similar averages from 2010. The cause of the increase is not known; however, it is most likely related to pump or wet well level issues. The average run time was 0.4 hours from 2012 to 2014 and has increased to about 0.6 hours in 2015 and 2016. The increase may be related to development; however, there have been many documented issues with the wet well level probe which may have increased run times.

The SCADA event log analysis indicates the lift station receives a relatively low average inflow rate of about 14 gpm. There may be some seasonal variation in the average flows to the station. A very large range in the calculated peak hour flows was observed, with variations of hundreds of gallons per minute. The maximum peak hour inflow was 664 gpm in August 2015. The peak instantaneous flow was 703 gpm and occurred in September of 2015. The discrepancy between average and peak flow rates may be due to level probe errors.

3.6.1.3 Electricity Usage and Pump Run Times

Electrical demand and usage at the SID #78 Lift Station was provided by the City for January 2013 to September 2016. The records report monthly energy usage in kWh and power demand in kW. By dividing the energy usage by the demand, the pumping hours can be estimated. Table 3-12 presents the energy usage, demand, and pump run times predicted at the lift station.

Table 3-12 SID #78/Truck Stop Lift Station Power Usage				
Year	**Total Energy Used**	**Average Energy Demand**	**Annual Pump Run Time(1)**	**Average Daily Pump Run Time**
2013	11,197 kWh	5.3 kW	2,260.5 hrs	6.2 hrs/day
2014	11,749 kWh	5.5 kW	2,425.3 hrs	6.6 hrs/day
2015	14,124 kWh	8.1 kW	1,991.3 hrs	5.5 hrs/day
2016(2)	12,106 kWh	9.0 kW	1,525.6 hrs	5.6 hrs/day
Average	***12,294 kWh***	***7.0 kW***	***2,050.7 hrs***	***6.0 hrs/day***

(1)Calculated using the monthly energy usage and demand.
(2)January to September.

Like the other lift stations, the electricity usage analysis is an overestimate of the pump run time. The SID #78 Lift Station also includes a climate controlled generator building which would increase the energy usage at the station. The SCADA run times are considered valid at the location.

3.6.1.4 Capacity Summary and Conclusions

The various field tests and calculations indicate the following:

- Lift station pumping capacity:
  - Current = 300 gpm
- Average day inflow = 14 gpm
- Peak hour inflow = 664 gpm
- Peak instantaneous inflow = 703 gpm
- Average pump run time:
  - Historical = 0.4 hours per day
  - Current = 0.6 hours per day

As discussed previously, the level probe may be affecting the function of the pumps and artificially increasing peak hour and peak instantaneous flow rates. It is recommended that the issue with the level probe be resolved prior to assessing the capacity of the SID #78 Lift Station. It should not be operating at capacity since it was designed to accommodate full buildout of both SID #78 and the SID #78 future planning area.

3.6.2 Condition and Deficiencies

TD&H Engineering conducted a site visit to the SID #78 Lift Station on October 20, 2016 to document the station's condition by visual observation of the components, verbal reports from City personnel, and field data. Table 3-13 presents a summary of the main components in the station, their condition, and recommended improvements. The operator's logs are summarized in Appendix 3 and typically list the date of repairs and control panel errors.

Table 3-13 SID #78 Lift Station Equipment Condition and Recommendation Summary		
Component	**General Condition**	**Recommendation**
Submersible Pumps	Questionable run times.	Replace level probe.
Pump Motors	Near end of useful life; no issues reported.	OK
Wet Well Structure	Concrete; good condition; inverted "j" tube vent present;	OK
Wet Well Piping and Fittings	Some light corrosion is visible.	OK
Level Monitoring	Almost daily history of probe errors.	Replace probe and consider the addition of a stilling tube.
Pump Lift Rails	Project specifications indicate stainless steel was required, minimal visible corrosion.	OK
Valve Vault	Concrete; adequate.	OK
Check valves	Adequate.	OK
Plug valves	Adequate.	OK
Emergency Bypass Piping	None indicated on original plans.	Add bypass piping connection in or near valve vault.
Controls	Located in generator building, functional, radio telemetry.	OK
Alarms	The following alarms are available: pump #1 fail, pump #2 fail, entry, power, pump #1 called, pump #2 called, high wet well, low wet well, generator run, gen. comm. Fail, gen. batt., ATS in Em. Pos., pump #1 seal, pump #2 seal, pump #1 temp, pump #2 temp, lag pump in op., operator present, and door switch.	OK
Electrical	Located in generator building; backup power provided for emergency pumping.	OK
Generator Building	Good condition	OK

The overall condition of the station infrastructure, including the building and buried concrete structures, is good. The lift station has only been in operation since 2009; however, there have been many issues with the level monitoring probe and with the pumps. The operator logs indicate that probe errors have been recorded nearly every day for two years. In addition, the station does not appear to include an emergency bypass pumping connection.

It is recommended to replace the level probe and investigate the addition of a stilling well or deflector panel at the influent pipe. Once the probe is replaced, a new draw down test should be performed to verify the pumping capacity. Finally, it is recommended to install an emergency pumping bypass connection in the valve vault to comply with Circular DEQ-2 requirements.

3.6.3 Force Main

A 6-inch PVC force main conveys flows from the lift station to a manhole in Amsterdam Road. The performance of the force main was analyzed using the design pumping rate due to the discrepancies in pump performance. Applying the design flow rate of 300 gpm, the force main velocity is 3.4 ft/sec. A calculation is provided in Appendix 3. Circular DEQ-2 requires a minimum cleaning velocity of 2 ft/sec and a maximum velocity of 8 ft/sec; the force main is adequate at the design flow.

3.7 LIFT STATION #5: MEADOWLARK/POWERS

Lift Station #5 is located on Powers Boulevard in the Meadowlark Ranch subdivision, east of the wastewater treatment plant, and was constructed in 2008. The lift station consists of a generator building, a circular concrete wet well with duplex pumping units, and a circular concrete valve vault. The Flygt model NP3085.183 submersible pumps with 3 HP motors were designed for 283 gpm at 22 ft TDH. According to the *Meadowlark Subdivision Lift Station Engineering Report* (Engineering, Inc. 2006), the Meadowlark Lift Station was designed for full build-out of the subdivision, or about 430 residences. To date, approximately 130 homes have been built. Figure 3-8 illustrates the boundaries of Meadowlark Lift Station and the planning area. Photos and notes from a site visit are provided in Appendix 3.

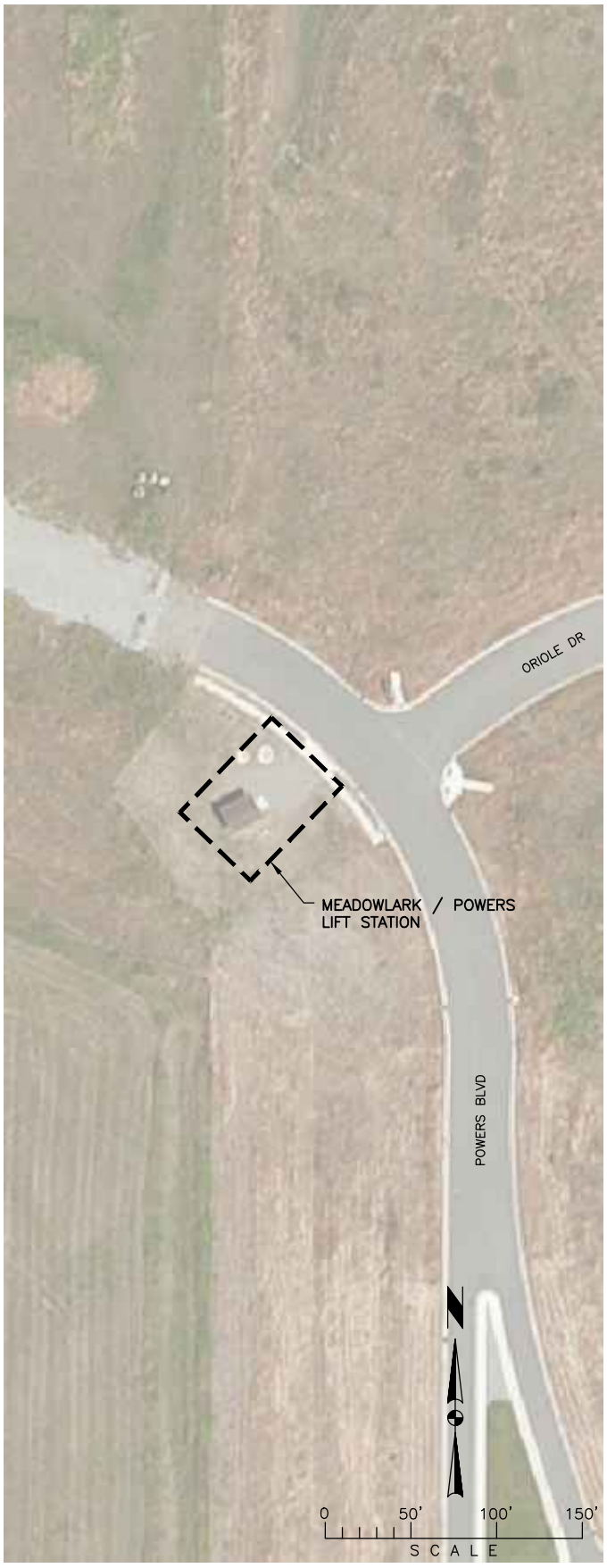
Flow from the Meadowlark Lift Station is routed through a 4-inch PVC force main to a nearby sewer manhole in Ryen Glenn Estates subdivision. From there, the wastewater flows through 8” PVC gravity mains until it reaches the Ryen Glenn Lift Station.

The City of Belgrade’s SCADA system continuously receives a variety of data, including but not limited to alarms, pump run times, and pump temperatures, from the Meadowlark Lift Station. The station is controlled with a pressure transducer in the wet well. Alarms are communicated through the SCADA system and radio telemetry to City personnel. Flow rates are not measured or reported; wet well depths, RTU temperature, and battery voltage are reported continuously.

SITE AND GENERATOR BUILDING

WET WELL

VALVE VAULT



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LIFT STATION #5: MEADOWLARK / POWERS

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DRAWN BY:	CJS
DESIGNED BY:	CEVJ
QUALITY CHECK:	
DATE:	04/28/2017
JOB NO.	B16-048
CAD NO.	FIG 3-X LIFT STATIONS

FIGURE
3-8

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 3-X LIFT STATIONS.dwg, 4/28/2017 3:34:47 PM, cjs

3.7.1 Capacity

The Meadowlark Lift Station is less than ten years old and there are few documented issues with the pumps. The station was sized for full buildout of the Meadowlark Ranch subdivision and, to date, Phase I and part of Phase II of the multi-phase project are complete. The lift station will not reach capacity until future phases are completed; therefore, the capacity of the station is considered equal to the peak hour flow and pumping rate described in the original design report. A detailed investigation and analysis of the capacity is not necessary. A draw down test was not completed and the SCADA event log data was not analyzed.

The pump run time records are an indicator of lift station performance and should reflect the development in the subdivision. Run times from the SCADA data were compared to run times calculated from electricity usage records. Calculations are provided in Appendix 3 and copies of the SCADA data are available electronically.

3.7.1.1 SCADA Pump Run Times

Daily pump run times are reported directly by the SCADA system and were evaluated from 2010 to 2016. Chart 3-6 presents the average pump run time from 2010 to 2016. The station run time is equal to the sum of the individual pump run times.

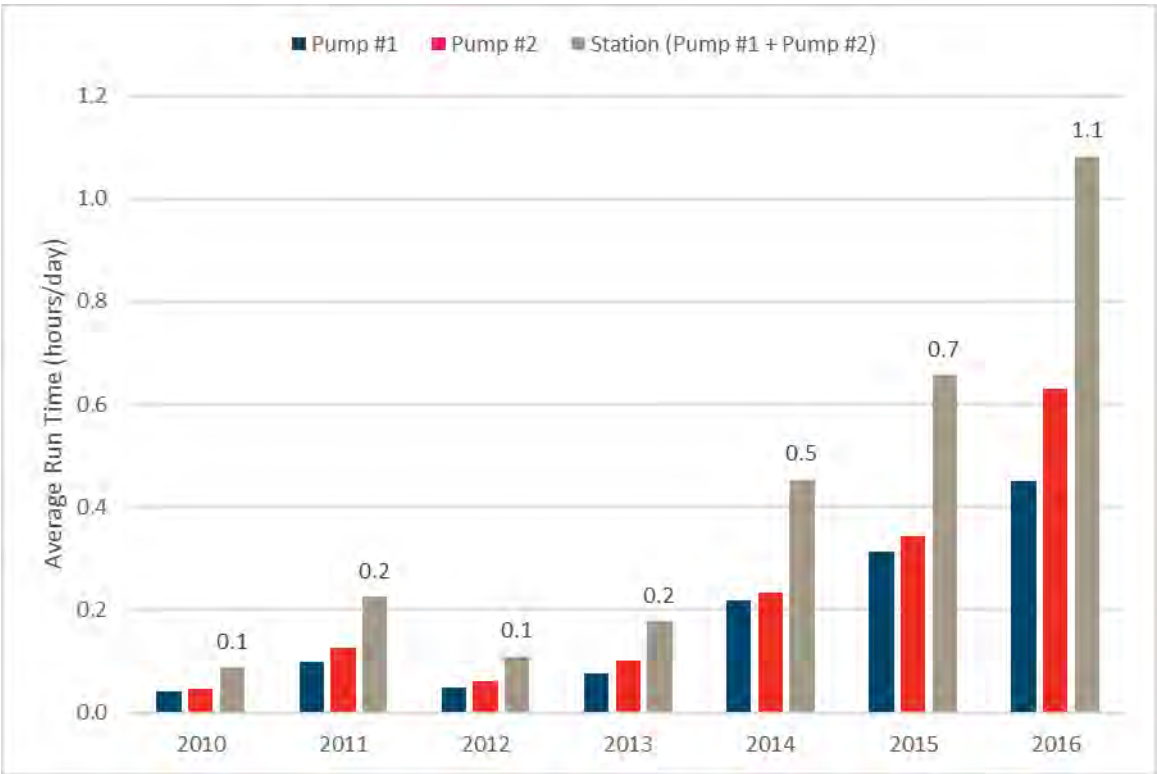


Chart 3-6. Meadowlark/Powers Lift Station Average Daily Pump Run Time

Pump run times have increased significantly since 2010 as more homes have been built in the subdivision. The average total run time in 2016 was 1.1 hours per day.

3.7.1.2 Electricity Usage and Pump Run Times

Electrical demand and usage at the Meadowlark Lift Station was provided by the City for January 2013 to September 2016. The records report monthly energy usage in kWh and power demand in kW. By dividing the energy usage by the demand, the pumping hours can be estimated; however, the station has a climate-controlled generator and controls building. The power demands from the building are expected to affect the electricity usage. Table 3-14 presents the energy usage, demand, and estimated pump run times.

Table 3-14
Meadowlark/Powers Lift Station Power Usage

Year	Total Energy Used	Average Energy Demand	Annual Pump Run Time[(1)]	Average Daily Pump Run Time
2013	7,255 kWh	3.3 kW	2,323.9 hrs	6.4 hrs/day
2014	8,381 kWh	3.2 kW	2,511.4 hrs	6.9 hrs/day
2015	7,144 kWh	2.5 kW	2,684.4 hrs	7.4 hrs/day
2016[(2)]	5,307 kWh	3.0 kW	1,693.4 hrs	6.2 hrs/day
Average	***7,022 kWh***	***3.0 kW***	***2,303.3 hrs***	***6.7 hrs/day***

[(1)]Calculated using the monthly energy usage and demand.
[(2)]January to September.

The average run times estimated by the electricity analysis are significantly higher than what was recorded by the SCADA system. The lights, heating, and other appurtenances in the generator building increase the energy usage; therefore, the pump run times reported by the SCADA system are considered correct. The run times in Table 3-14 are not representative of the station. It is recommended that the City perform an energy audit of the station and to create an inventory of all infrastructure which utilizes the lift station's electrical service. If it is discovered that other infrastructure or buildings are utilizing the lift station's service, the City should take corrective action.

3.7.1.3 Capacity Summary and Conclusions

The capacity of the lift station is defined by the original design and the current pump run times. The following summarizes the lift station capacity:

- Lift station pumping capacity:
  - Original = 283 gpm
- Average day inflow = 76 gpm (full buildout)
- Peak hour inflow = 283 gpm (full buildout)
- Average pump run time:
  - Historical = 0.2 to 0.7 hours per day
  - Current = 1.1 hours per day

The capacity of the existing station is adequate for the Meadowlark Ranch subdivision at full buildout, so it will be several years before the station reaches capacity. In order to monitor the pumps more closely, it is recommended to enable flow measurement capabilities in the local pump controller and to transmit the data to the City's SCADA system.

3.7.2 Condition and Deficiencies

TD&H Engineering conducted a site visit to the Meadowlark Lift Station on October 20, 2016 to document the station's condition by visual observation of the components, verbal reports from City personnel, and field data. Table 3-15 presents a summary of the main components in the station, their condition, and any recommended improvements. The operator's logs, through December 2016, are summarized in Appendix 3 and provide the date of repairs and control panel errors.

Table 3-15
Meadowlark/Powers Lift Station
Equipment Condition and Recommendation Summary

Component	General Condition	Recommendation
Submersible Pumps	OK; some recent issues with Pump 2 which have been resolved.	OK
Pump Motors	OK	OK
Wet well structure	Concrete; good condition; vents present	OK
Wet Well Piping and Fittings	OK, no corrosion visible	OK
Level Monitor	OK	OK
Pump Lift Rails	Stainless steel, good condition	OK
Valve Vault	Floor was damp; however, concrete in good condition and floor drain is visible	OK
Check valves	OK	OK
Plug valves	OK	OK
Emergency Bypass Piping	None	Install an emergency bypass pumping connection in the wet well.
Controls	Located in generator/control building; no reported problems.	OK
Alarms	The following alarms are available: pump #1 fail, pump #2 fail, entry, power, pump #1 called, pump #2 called, high wet well, generator run, gen. comm. Fail, gen. batt., ATS in Em. Pos., pump #1 seal, pump #2 seal, pump #1 temp, pump #2 temp, operator present, and door switch. DEQ requires both high and low-level alarms.	Install low level alarm in accordance with DEQ requirements
Electrical	Housed in separate generator/control building. Continual issues with power faults after construction; however, issue appears to be resolved.	OK
Generator Building	Good condition	OK

The Meadowlark Lift Station is less than ten years old and does not have any recurring operation or maintenance issues; however, the station was apparently designed without a quick connect pump bypass connection. This feature is required by Circular DEQ-2 to facilitate pump bypassing during repairs or maintenance. The control panel also does not appear to include a low wet well level alarm. It is recommended to add a bypass connection and to adjust the controls to include a low-level alarm in accordance with DEQ requirements.

3.7.3 Force Main

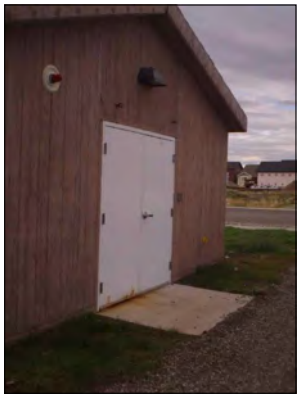
The velocity in the 4-inch PVC force main was analyzed to determine if the minimum cleaning velocity of 2 ft/sec is provided. When the pumps operate at the design flow of 283 gpm, the velocity in the force main is 7.2 ft/sec. The force main achieves a satisfactory cleaning velocity.

3.8 LIFT STATION #6: RYEN GLENN/PENWELL BRIDGE

Lift Station #6 is in the Ryen Glenn Estates subdivision north of the Meadowlark Ranch subdivision. The station is located on Penwell Bridge Road on a 1.695-acre parcel owned by 2B Holdings, LLC. It was constructed during 2007 and 2008. The lift station was designed to serve the Ryen Glenn Estates and Meadowlark Ranch subdivisions. The Ryen Glenn Lift Station consists of a mechanical building, a square concrete valve vault and a square concrete, vented wet well with two submersible pumps. The 30 HP, 1,755 RPM submersible pumps have a design capacity of 520 gpm at 99 ft TDH. Documentation from the developer indicates that the design peak hour flow for just the Ryen Glenn Estates subdivision is 271 gpm. Figure 3-9 presents the location and layout of Ryen Glenn Lift Station. Photos and notes from a site visit are provided in Appendix 3.

Wastewater from the Meadowlark Lift Station and the Ryen Glenn Estates subdivision flows through the Ryen Glenn Lift Station and is discharged through an 8-inch PVC force main to a manhole at the southwest corner of the treatment ponds. The flow is discharged just upstream of the flow measurement vault.

The City of Belgrade's SCADA system continuously receives alarms and pump run times from the Ryen Glenn Lift Station. The station is controlled with a level sensor in the wet well. Alarms are communicated through the SCADA system and radio telemetry to City personnel. The Ryen Glenn Lift Station is the only installation which reports a pumping rate directly to the SCADA system. Wet well level, RTU temperature, and battery voltage are continuously recorded.

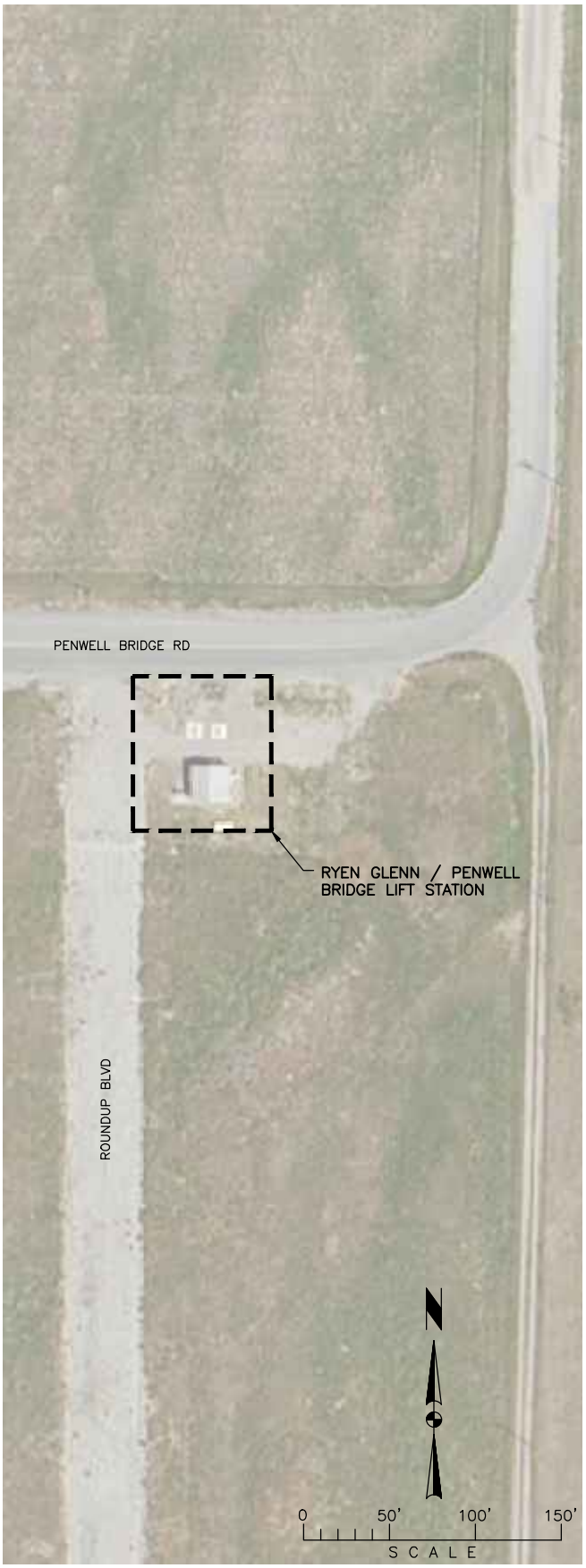


GENERATOR BUILDING

VALVE VAULT

WET WELL

SITE



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BELGRADE, MONTANA

LIFT STATION #6: RYEN GLENN / PENWELL BRIDGE

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DRAWN BY:	CJS
DESIGNED BY:	CEVJ
QUALITY CHECK:	
DATE:	04/28/2017
JOB NO.	B16-048
CAD NO.	FIG 3-X LIFT STATIONS

FIGURE
3-9

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 3-X LIFT STATIONS.dwg, 4/28/2017 3:35:00 PM, cjs

3.8.1 Capacity

The Ryen Glenn Lift Station is less than ten years old and there are few documented issues with the pumps. The station was sized for full buildout of the Ryen Glenn Estates and Meadowlark Ranch subdivisions. Neither has been developed to full buildout. The lift station will not reach capacity until both subdivisions are fully developed; therefore, the capacity of the station is considered equal to the peak hour flow and pumping rate described in the original design report. A detailed investigation and analysis of the capacity is not necessary. A draw down test was not completed.

Unlike the other lift stations, the City's SCADA system does not appear to record the time and date of events such as pumps turning on and off, alarms, and generator tests. Without this "event log" data, the inflow rate to the lift station cannot be estimated. As discussed above, the station has not accumulated the operating hours and associated wear to warrant a full analysis; however, it is recommended that this functionality be activated in the SCADA system to facilitate future monitoring and analysis.

The pump run time records are an indicator of lift station performance and should reflect the development in the subdivision. Run times from the SCADA data were compared to run times calculated from electricity usage records. Calculations are provided in Appendix 3 and copies of the SCADA data are available electronically.

3.8.1.1 SCADA Pump Run Times

Daily pump run times are reported directly by the SCADA system and were evaluated from 2010 to 2016. Chart 3-7 presents the average pump run time from 2010 to 2016. The station run time is equal to the sum of the individual pump run times.

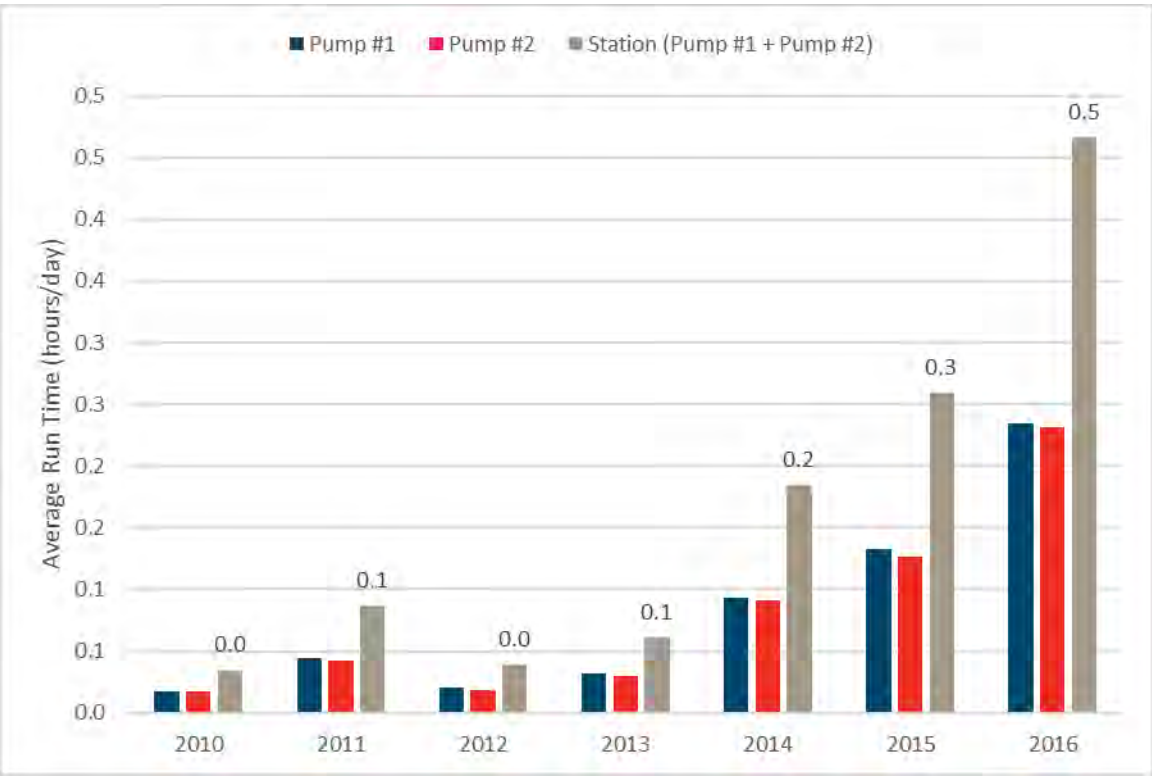


Chart 3-7. Ryen Glenn/Penwell Bridge Lift Station Average Daily Pump

Pump run times have increased since 2010 as more homes have been built in the subdivisions; however, the total run time is quite small considering the pumping capacity. The average station run time in 2016 was 0.5 hours per day.

3.8.1.2 Electricity Usage and Pump Run Times

Electrical demand and usage at the Ryen Glenn lift station was provided by the City for January 2013 to September 2016. The records report monthly energy usage in kWh and power demand in kW. By dividing the energy usage by the demand, the pumping hours can be estimated; however, the station has a climate-controlled generator and control building. The power demands from the building are expected to affect the electricity usage. Table 3-16 presents the energy usage, demand, and estimated pump run times.

Table 3-16
Ryen Glenn/Penwell Bridge Lift Station Power Usage

Year	Total Energy Used	Average Energy Demand	Annual Pump Run Time(1)	Average Daily Pump Run Time
2013	6,871 kWh	6.6 kW	1,068.5 hrs	2.9 hrs/day
2014	8,081 kWh	6.3 kW	1,292.2 hrs	3.5 hrs/day
2015	8,098 kWh	5.8 kW	1,385.9 hrs	3.8 hrs/day
2016(2)	7,512 kWh	5.8 kW	1,312.3 hrs	4.8 hrs/day
Average	***7,641 kWh***	***6.1 kW***	***1,264.7 hrs***	***3.8 hrs/day***

(1)Calculated using the monthly energy usage and demand.
(2)January to September.

The average run times estimated by the electricity analysis are higher than what was recorded by the SCADA system. The lights, heating, and other appurtenances in the generator building increase the energy usage; therefore, the pump run times reported by the SCADA system are considered correct. The run times in Table 3-16 are not representative of the station.

3.8.1.3 Capacity Summary and Conclusions

The capacity of the lift station is defined by the original design and the current pump run times. The following summarizes the lift station capacity:

- Lift station pumping capacity:
  - Original = 520 gpm
- Peak hour inflow = 520 gpm
- Average pump run time:
  - Historical = 0.1 hours per day
  - Current = 0.5 hours per day

The capacity of the Ryen Glenn Lift Station is adequate for both the Ryen Glenn Estates and Meadowlark Ranch subdivisions at full buildout, so it will be some time before it reaches capacity. It is recommended to adjust the flow rate measured in the SCADA

system to match either the pumping rate, measured with a draw down test, or the nominal pump capacity.

3.8.2 Condition

TD&H Engineering conducted a site visit to the Ryen Glenn Lift Station on October 20, 2016 to document the station's condition by visual observation of the components, verbal reports from City personnel, and field data. Table 3-17 presents a summary of the main components in the station, their condition, and any recommended improvements. The operator's logs, through December 2016, are summarized in Appendix 3 and provide the date of repairs and control panel errors.

Table 3-17
Ryen Glenn/Penwell Bridge Lift Station
Equipment Condition and Recommendation Summary

Component	General Condition	Recommendation
Submersible Pumps	OK.	OK
Pump Motors	OK	OK
Wet well structure	Concrete; good condition; vent present	OK
Wet Well Piping and Fittings	OK, no corrosion visible	OK
Level Monitor	OK	OK
Pump Lift Rails	Stainless steel, good condition	OK
Valve Vault	Floor was damp; however, concrete in good condition and floor drain is visible	OK
Check valves	OK	OK
Plug valves	OK	OK
Emergency Bypass Piping	None	Add an emergency bypass pumping connection in the wet well.
Controls	Located in generator/control building; no reported problems. Pump station event data does not appear in the SCADA system; this should be available for City records and to facilitate capacity calculations.	Enable station event log reporting like the other lift stations.
Alarms	The following alarms are available: pump #1 fail, pump #2 fail, entry, power, high wet well, low wet well, generator run, gen. comm. Fail, gen. batt., ATS in Em. Pos., operator present, and door switch.	OK
Electrical	Housed in separate generator/control building.	OK
Generator Building	Good condition	OK

The age and condition of the Ryen Glenn Lift Station are similar to the Meadowlark Lift Station. Ryen Glenn is less than ten years old and does not have any recurring operation or maintenance issues; however, the station was apparently designed without a quick connect pump bypass connection. This feature is required by Circular DEQ-2 to facilitate pump bypassing during repairs or maintenance. It is also the only lift station that does not record the timing of pump events and alarms in the SCADA system event log. It is recommended to add a bypass connection and to adjust the pump control panel or central SCADA system to record alarms and pumping events.

3.8.3 Force Main

The velocity in the 8-inch PVC force main was analyzed to determine if the minimum cleaning velocity of 2 ft/sec is provided. When the pumps operate at the design flow of 520 gpm, the velocity in the force main is 3.3 ft/sec. The force main achieves a satisfactory cleaning velocity.

3.9 LIFT STATIONS PLANNED OR UNDER CONSTRUCTION

Several developers have approached the City of Belgrade with plans for new subdivisions in the northeast corner of the planning area. As of May 2017, a new lift station for Phase 1 of the Henson subdivision is under contract and should begin construction in the summer of 2017. Some aspects of the design of the station were selected based on plans for other future subdivisions and growth in the area. An explanation of those provisions will be provided in Chapter 6 of this Master Plan. The location of the lift station and the new lots is provided in Appendix 3. The proposed lift station will be located at the intersection of Beeker Lane and Westwood Circle. The force main will be connected directly to the existing 10-inch force main in Cruiser Lane. The engineer's design report indicates the peak hour sewer flow for the Phase 1 improvements is 175 gpm. Final design of various aspects of the station is underway; however, the capacity of the pumps is expected to remain at 175 gpm.

4.0 TREATMENT AND DISPOSAL EXISTING FACILITY REVIEW

The existing Belgrade Wastewater Treatment Plant (BWTP) is located northeast of the City of Belgrade. It is a 3-celled, partially aerated lagoon system, constructed in 2004. The plant discharges treated wastewater to 3 IP Beds and a spray irrigation system. The following chapter details the components, condition and capacity of the existing treatment and disposal systems and the plant's existing controls. All raw data downloaded from the City's SCADA system and the DEQ's Discharge Monitoring Reports (DMRs) is available for review in electronic form in the Appendix.

4.1 Existing Plant Loading

In order to gain a thorough understanding of the existing treatment plant, it is necessary to assess the hydraulic, nutrient and organic loading. The available flow and water quality data are evaluated in the following sections.

4.1.1 Hydraulic Loading

The BWTP includes four flow meters. The influent flow is measured at the head of treatment plant with an ultrasonic open channel flow meter. Two magnetic flow meters have been installed on the discharge piping to measure effluent. An additional meter measures the recycle stream. Each flow meter is connected to the City's SCADA system and records flow rates in gpm at six minute intervals.

4.1.1.1 Influent Flow

The influent flow data, originally presented in Chapter 3, was measured at the head of the BWTP. This analysis estimates the existing average day flow rate at 716,737 gpd. The maximum month, maximum day, peak hour and peak instantaneous flow rates were estimated in Chapter 3 from available SCADA data. Average peaking factors for each flow type were determined and multiplied by the average day flow. It was estimated that the maximum month flow rate is 1,032,101 gpd, the maximum day flow is 1,426,307 gpd and the peak hour and peak instantaneous flows are 2,365,232 and 3,003,128 gpd, respectively. This information is summarized in Table 4-1. As mentioned in Chapter 3, the inflow meter may not be extremely accurate. A technician recently inspected the meter calibration which indicated the setup data may have included an error. The type of meter currently in use does not provided a high level of accuracy. A comparison was made versus water system metered flow records which further indicates the inflow meter may be overestimating the influent data. For the purposes of this master plan the data should be considered relatively conservative and should be confirmed prior to final design for any new improvements.

Table 4-1 Existing Influent Flow Rates	
Demand	**Flow Rates (gpd)**
Average Day Flow	716,737
Maximum Month Flow	1,032,101
Maximum Day Flow	1,426,307
Peak Hour Flow	2,365,232
Peak Instantaneous Flow	3,003,128

4.1.1.2 Effluent Flow

The BWTP discharges treated wastewater to four separate outfalls, 3 IP beds (known as IP Beds A, B and C) and a spray irrigation system. Two discharge pipes transport treated effluent from the lagoons; one discharge main conveys effluent to IP Beds A and B and the second transports treated wastewater to the irrigation system and IP Bed C. A magnetic flow meter exists on each discharge pipe. Monthly average discharge rates are illustrated in Chart 4-1. Raw SCADA data is provided in electronic form. The recent meter verification performed by M.E.T. Automation and Controls confirmed the magnetic flow meters on the discharge piping were producing accurate measurements. The detailed calibration report is included in Appendix 3.

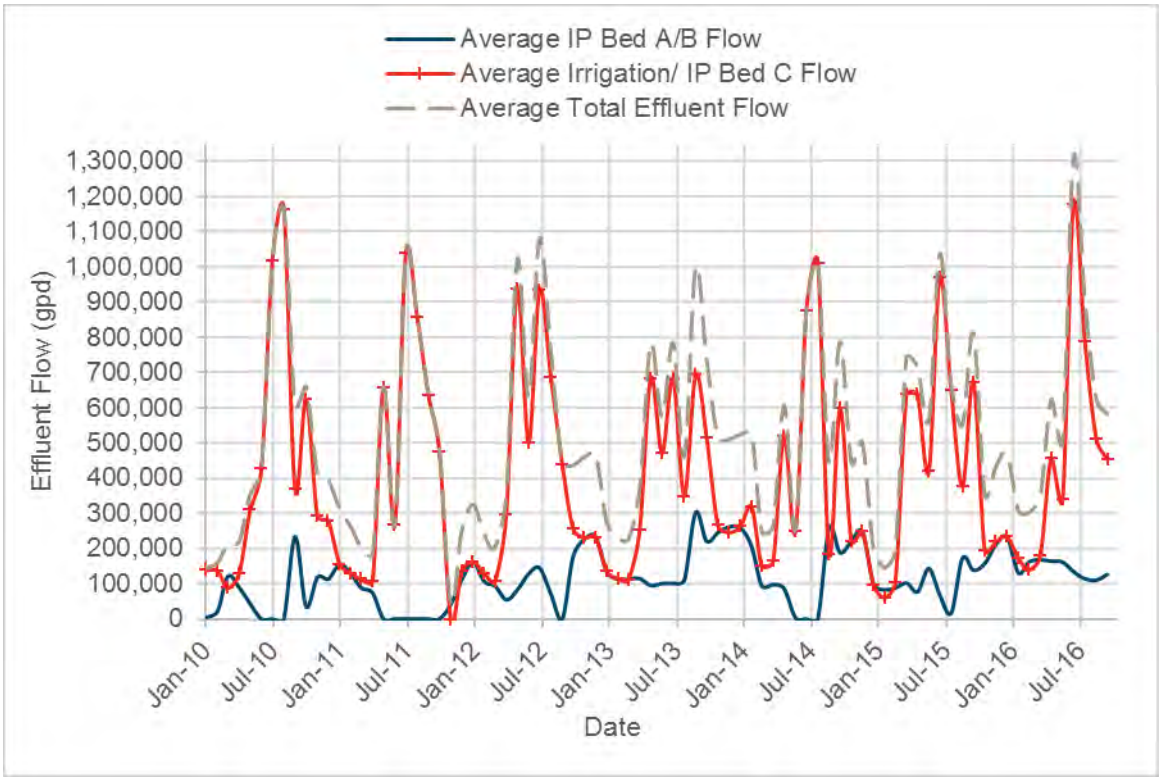


Chart 4-1: **Existing Effluent Flow Rates**

The City discharges its treated wastewater year-round. Average discharge rates are notably larger in the warmer months, during which most of the treated wastewater is discharged to the irrigation system and IP Bed C. In the winter months, when irrigation is not available, average flow rates through both discharge lines are roughly equivalent. The total effluent flow rate has steadily increased since 2010. The yearly average effluent flow rate in 2010 was roughly 480,000 gpd; the yearly average effluent flow rate in 2016 was approximately 600,000 gpd. Due to the increase in Belgrade's population, a gradual increase in wastewater flow over the past 6 years was anticipated.

Similar to the influent flow measurements, the average day combined effluent flows were compared against estimated populations to calculate a per capita effluent flow. From 2014 to 2016, the per capita combined effluent flow ranged from 66.4 gpcd to 71.8 gpcd. This data is summarized in Table 4-2. Effluent flow is noticeably less than the influent per capita flow rate and recommended DEQ values. When comparing the combined effluent flows to the influent flows previously discussed, the average influent flow rate is consistently 100,000 gpd greater than the average day effluent flow. Because the effluent flow meters were confirmed to be accurate during the meter calibration tests, influent vs effluent flow comparisons further suggest the influent flow meter may not be providing highly accurate information. It is also possible that the basin liners may be leaking. Prior to any major system improvements, a more accurate inflow meter and a hydrostatic leakage test of the ponds is recommended.

Table 4-2
Historic Average Day Effluent Flows

Year	Average Day Combined Effluent Flow (gpd)	Estimated Population (persons)	Calculated Per Capita Effluent Flow (gpcd)
2014	541,407	7,798	69.4
2015	536,020	8,071	66.4
2016	599,631	8,353	71.8

4.1.2 Nutrient and Organic Loading

The City of Belgrade collects influent and effluent water samples to monitor water quality. The samples are sent to Energy Laboratories, Inc. in Billings, MT to determine concentrations of ammonia, TN, TSS, TKN and phosphorous. As discussed in Chapter 2, the City's treatment and disposal system is designed to meet the permit allowable TN concentrations. Measured TN concentration in the influent and effluent are presented in Chart 4-2. Additional contaminant charts as well as the raw tabular data are available for review in Appendix 4.

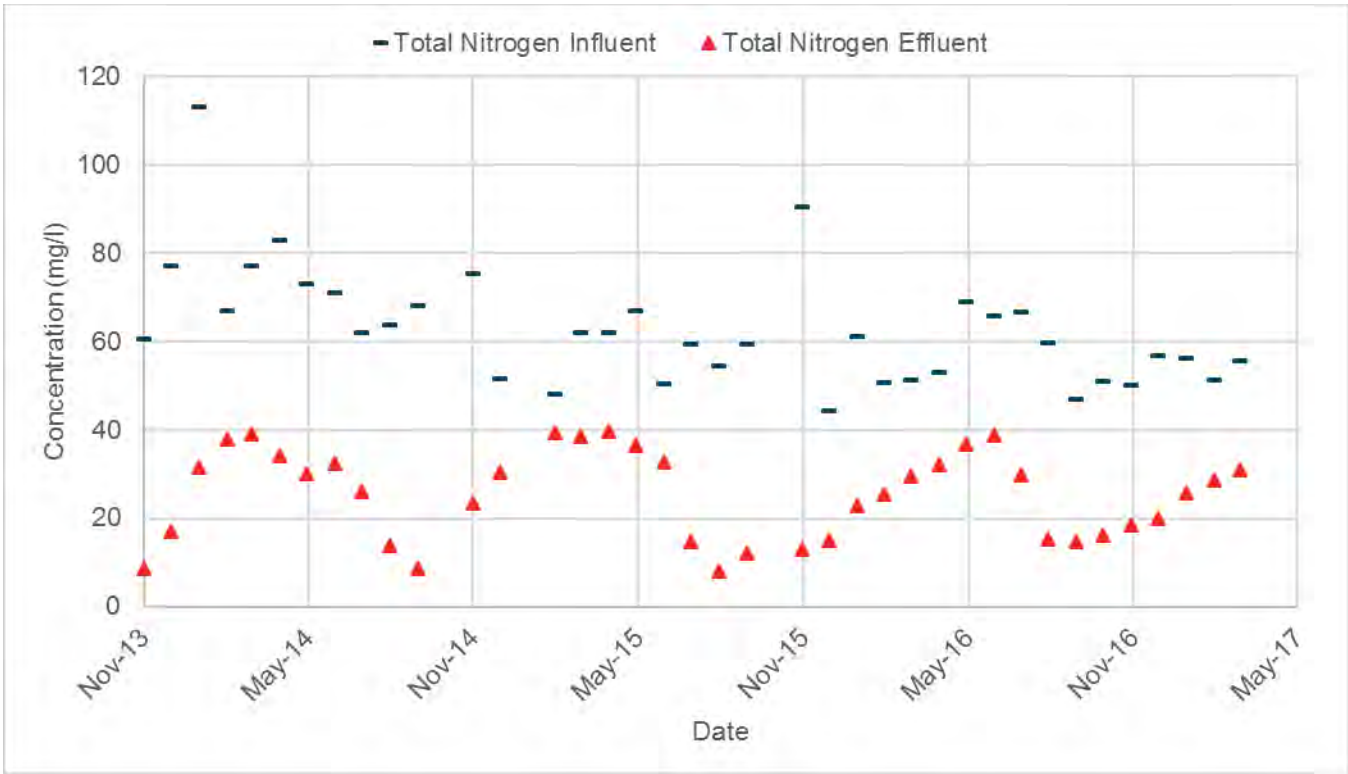


Chart 4-2: Treatment Plant Influent and Effluent Total Nitrogen Concentrations

Influent TN concentrations range from roughly 80 mg/l to than 45 mg/l.. These influent nitrogen concentrations are higher than typical domestic nitrogen levels which are commonly in the range of 20 to 85 mg/l and average roughly 40 mg/l (Metcalf and Eddy). The higher concentrations may be a result of the use of low flow fixtures as well as any industrial customers which may discharge high nutrient concentration waste. Food processors handling meet, cheese, or plant waste could be contributors. Many communities track high strength waste customers and either require pretreatment or increased user rates for those types of customers.

The effluent TN concentrations have experienced a seasonal pattern over the past 4 years. Concentrations are consistently lowest in the late summer and fall. This is most likely due to the elevated temperature in the summer months. As the ambient air temperature decreases, the nitrification process in the lagoons becomes considerably less effective. Thermal regulation of the treatment lagoons could significantly increase the treatment efficiency and reliability.

4.2 Wastewater Treatment Plant

The BWTP is located in Section 36, Township 1 North, Range 3 East. It was converted from a 4-celled facultative system to a lined, 3-celled partially mixed aerated system in 2004. The current treatment basins are lined with a 60 mil HDPE liner. The flow through mechanically aerated system operates with 2 lagoons for treatment and one for storage. Aerated lagoons are similar to conventional facultative lagoons in that they rely on natural microorganisms to treat the impounded wastewater. Aerated lagoons include the mechanical addition of air to provide oxygen, minimize algae growth and provide mixing that accelerates and improves the treatment efficiency. The microorganisms, primarily algae and bacteria, utilize the constituents of wastewater as a food source for growth. The microorganisms either settle to the bottom of the treatment pond or are discharged to the receiving water.

The BWTP was designed to achieve secondary treatment. Secondary treatment involves the removal of settleable and dissolved solids and the stabilization of organic compounds. Piping within the plant allows for both parallel and series operations. In recent years, the plant has been operated in series during the summer months and parallel in the winter months in an attempt to mitigate odor issues. The most recent discharge permit application proved that the BWTP was achieving levels of TN reduction equal to or better than DEQ's Level 2 designation.

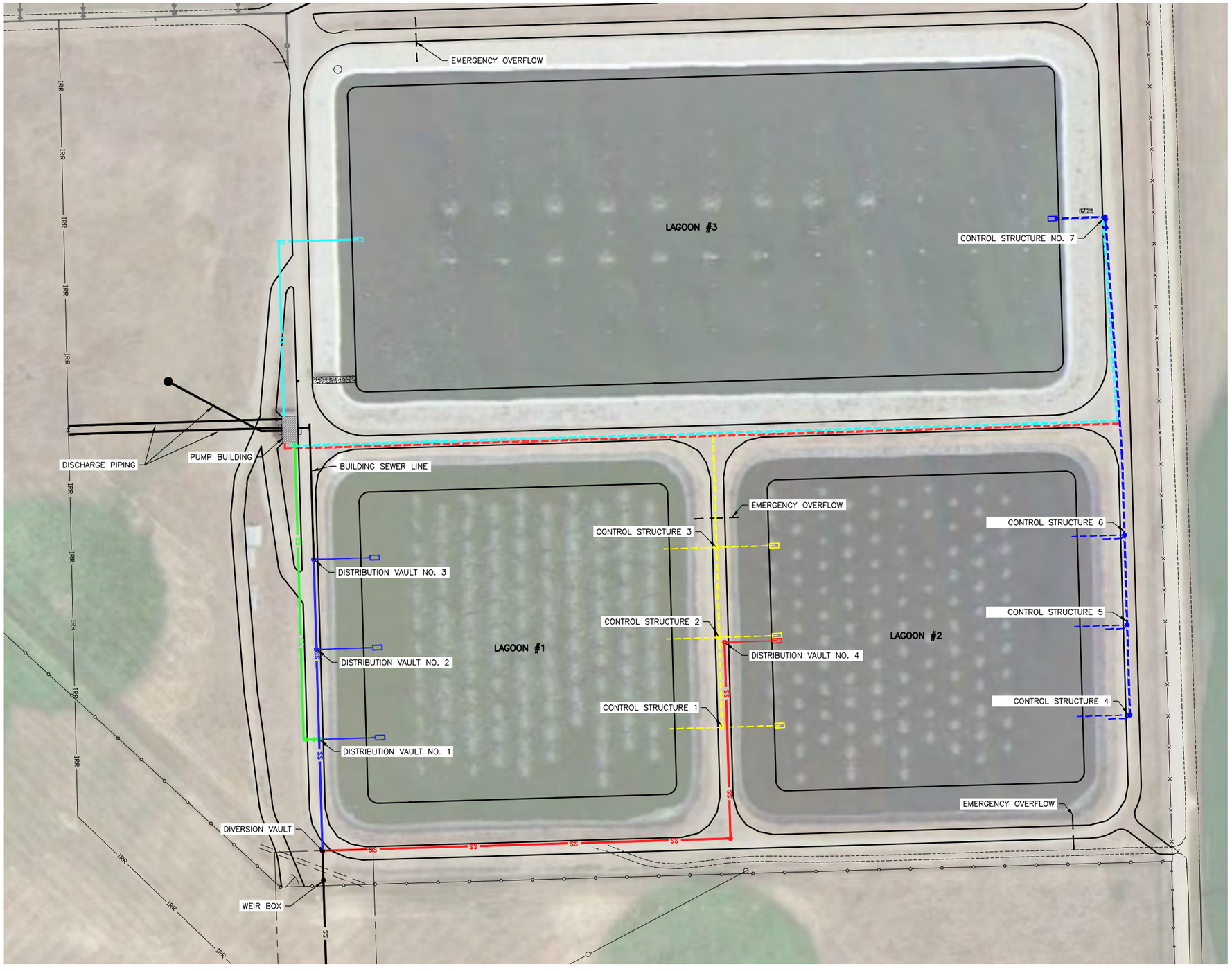
Components of the BWTP, including lagoons, piping and aeration system, are detailed in the following sections. An overall schematic of the BWTP, including piping and control structures, is shown in Figure 4-1. Photographs from TD&H Engineering's 2016 site visit are provided in Appendix 4.

4.2.1 Lagoons

As mentioned previously, the BWTP is a system of three lagoons. The two smaller lagoons, located on the south side of the plant, are partially mixed aerated treatment lagoons. For the purpose of this Master Plan, the treatment cells will be referred to as Lagoon #1 and #2. The larger lagoon on the north side, Lagoon #3, is the storage and polishing pond. Existing conditions of the three lagoons are detailed below and summarized in Table 4-3.

Table 4-3
Current Treatment System

Lagoon	1	2	3	Total
Purpose	Treatment	Treatment	Storage	
Operating Surface Area (acres)	7	7	15.8	29.8
Operating Liquid Level (ft)	10	10	19.25	39.25
Sludge Depth (ft)	2	2	1	5
Freeboard (ft)	7	7	3	17
Detention Time (days)	17.7	17.7	90	125.4
Operating Capacity (MG)	16	16	81.5	113.5
Design Capacity (MGD)				903,000



LEGEND

SS	BY–PASS LINE
SS	DISTRIBUTION LINE
SS	OUTFALL LINE
SS	OUTLET LINE
SS	RECYCLE LINE
	TRANSFER LINE A
	TRANSFER LINE B
	TRANSFER LINE C
	TRANSFER LINE D

N

0 80' 160' 240'
SCALE

NOT FOR CONSTRUCTION

REV	DATE	REVISION

TD&H Engineering
406.761.3010 • tdhengineering.com
1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY: CJS
DESIGNED BY:
QUALITY CHECK:
DATE: 04/05/2017
JOB NO. B16-048
FIELDBOOK

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MT

EXISTING TREATMENT PLANT

FIG 4-1.DWG

FIGURE 4-1

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 4-1.dwg, 3/30/2018 4:42:15 PM, NMR

4.2.1.1 Treatment Lagoons

Lagoons #1 and #2 are the primary treatment lagoons located at the southwest and southeast sections of the treatment system, respectively. Per the record drawings, each treatment lagoon is lined with unprotected 60 mil High Density Polyethylene (HDPE) liner and has an operating capacity of roughly 16 million gallons (MG). The water surface area and operating depth of each lagoon is approximately 7 acres and 10 feet, respectively. Seven feet of freeboard is available to each lagoon. The bottom two feet are reserved for sludge accumulation. Each of the treatment lagoons have a 17.7 day detention time at the plant's design capacity of 903,000 gpd.

4.2.1.2 Storage Lagoon

Lagoon #3 is the storage and polishing cell and is located at the northern end of the BWTP. The record drawings indicate it has an operating depth of 19.25 feet with 1 foot at the bottom reserved for sludge accumulation and 3 feet of freeboard. The storage lagoon has an operating capacity of approximately 81.5 MG with a 90 day detention time at design capacity. The water surface area of the Lagoon #3 is 15.8 acres. Unlike the treatment basins, the storage lagoon has a thin layer of rip rap along the interior slopes of the pond to protect the HDPE liner from damage caused by the fluctuating water level and wave action.

A quiescent zone is located at the west end of the storage lagoon prior to discharge. This allows the remaining suspended solids to settle to the bottom. The treated wastewater then passes through one of two 18-inch stainless steel screens prior to being discharged. Each screen has 1/8-inch openings and a 3,400 gpm (4.9 MGD) capacity. An air-burst back flush system is included to clean the screens when necessary. A 175 psi Quincy compressor with a 120 gallon storage tank is capable of providing 24 cfm air flow to the screens. The compressor builds up air pressure and discharges to the intake screens to clean off debris, algae or other particles. The compressor is located on the top floor of the pump house.

4.2.1.3 Condition

Interviews with the City of Belgrade staff and a site walk through inspection suggest the plant is generally in good condition. No major issues associated with dike erosion or lagoon quality were reported; nor were any problems associated with the air-burst black flush system indicated. The plant operator, Mr. Paul Burkardt, estimates the air-burst back-flush system has been used 3 or 4 times since it was installed in 2004. Because it has been rarely used, Mr. Burkardt reports the system is in good condition.

Effluent flow rates are low when compared to estimated populations and influent flow meter rates. A detailed water balance was performed for November 2016 to January 2017. This water balance considered the influent flow rate (with corrections as applied based on calibration settings discovered by MET) and measured precipitation from the Bozeman-Yellowstone International Airport's weather station as the inflow data. Outflows were defined as all recorded discharge flows including flows to both irrigation and IP beds. Evaporation was not considered an outflow as the water balance only included winter months, when evaporation was considered negligible. Additionally, changes in water depth in Lagoon #3, as reported by the SCADA system, were utilized to account for change in water storage within the ponds. According to City staff, the level transducer originally used to measure water depth in the treatment ponds is no

longer functioning. However, the plumbing of the BWTP, discussed in the following section, has been designed to allow for gravity flow between ponds and will likely maintain relative constant water depths within Lagoons #1 and #2. For this reason, the water depths in the treatment lagoons were assumed to be constant for the purpose of the water balance. The volume of unaccounted for water was then calculated by applying the basic mass balance concept, assuming the volume is a conserved quantity. As such, the unaccounted-for water was calculated as the inflow (measured SCADA influent flow and precipitation) minus the effluent flows minus the measured change in Lagoon #3's water volume. Percent unaccounted for water was determined by taking the calculated unaccounted for water divided by the total inflow. Finally, estimated seepage was found by dividing the amount of unaccounted for water by the overall area of the three lagoon cells.

It was estimated that between November 2016 to January 2017 the percent of unaccounted for water ranged from 14.0% to 26.5%, this equates to a seepage rate of roughly 50 in/year. The results of the water balance are summarized in Table 4-4; the detailed water balance is provided in Appendix 4.

Table 4-4
Treatment Plant Water Balance Summary

Month	Inflow [1] (CF)	Adjusted Inflow[2] (CF)	Outflow (CF)	Change in Water Volume (CF)	Unaccounted for Water (CF)	% Unaccounted for Water (%)	Estimated Seepage (in/year)
November 2016	3,090,113	2,218,268	907,791	722,446	588,031	26.5%	66.1
December 2016	3,147,375	2,273,704	1,051,758	828,059	393,887	17.3%	42.9
January 2017	1,485,182	1,065,668	430,228	486,475	148,965	14.0%	16.8

[1] Inflow data considered elevated due to meter influent water meter malfunctions. See M.E.T. Automation and Control's Flow Verification Report, included in Appendix 3.

[2] Influent flow adjust by 71.5% based on information presented in flow verification report. Adjust inflow data values include both the adjusted influent flow rates and available precipitation data.

Even with the influent flow measurement calibration correction factor, the influent flow estimates are not considered sufficiently accurate. Thus, any potential for leakage should be field verified through a hydrostatic test before major capital improvements are considered.

A separate analysis was completed comparing estimated annual drinking water consumption versus wastewater effluent discharge for 2015. The City's Waster Master Plan, being prepared in conjunction with this Master Plan, was referenced for the 2015 water production rate. This value included residential, small commercial and large commercial flow rates for winter months in 2015. The water production rate was added the total precipitation rate to estimated total inflow. Precipitation data was obtained from the Bozeman-Yellowstone International Airport's weather station records for 2015. Total effluent was calculated by adding the BWTP average discharge rate for 2015 and the estimated lake evaporation value. Lake evaporation was estimated at 70% of the weather station's pan evaporation data. This analysis estimates nearly 20 inches of seepage in 2015. This analysis is summarized in Table 4-5.

Table 4-5 Drinking Water Consumption vs. Wastewater Effluent		
Water Production	608,000	gpd
BWTP Discharge	536,000	gpd
Evaporation	26.4	in
	58,027	gpd
Precipitation	13	in
	29,931	gpd
Total Inflow	637,931	gpd
Total Effluent	594,027	gpd
Estimated Leakage	**43,904**	**gpd**
	19.9	**in**

Evidence of minor liner damage above the high water mark was noted in the October 2016 site visit, performed by TD&H Engineering staff. Photo 4-1, taken during the recent site visit, shows a puncture in one of the treatment lagoon liners. Given the high hydraulic conductivity of the soils beneath the liner, even minor liner punctures can cause significant seepage.

Photo 4-1: Treatment Lagoon Liner Puncture

The above analysis suggests a possibility that treatment lagoon liners could be leaking. However, due to the high cost of liner replacement and questionable inflow and water level data, it is strongly suggested to assess a more detailed water balance after more accurate inflow data is available. If analysis confirms significant leakage, the advantages and disadvantages of a spot repair over a complete liner replacement should be considered. In both cases, the ponds would need to be drained and sludge removed.

Research performed by the Geosynthetic Institute in June 2005 and updated in February 2011 suggests that exposed HDPE liner has a life expectancy of greater than 36 years. Based on this information, the City's current liner could last another 20 years. Additionally, the capital costs associated with a complete liner replacement would be considerably higher than spot repair. However, spot repair is not an exact science and multiple attempts to repair the liner and stop leaks could be needed. Each attempt to repair the liner will cause an increase in overall construction costs.

Another issue associated with the lagoons is the sludge accumulation. A June 20, 2015 site visit by H&S Environmental, LLC was completed at the request of DEQ. During that site visit an estimated 1.55 feet of sludge accumulation has occurred in Lagoon #1. It has been conservatively assumed that equal amounts of sludge exist in Lagoons #1 and #2. H&S Environmental approximated the total sludge volume at 5.6 MG. Using the average end area method to verify the sludge volume estimate, approximately 5.3 MG of sludge was calculated. This calculation is provided in Appendix 4. Not only does the sludge take away from the normal operating capacity and detention time of the system, it can also cause nutrient feedback that results in excessive algae bloom, high TSS levels and possible TN permit failures. The complete evaluation report by H&S Environmental is available in Appendix 4.

4.2.1.4 Capacity

In order to accurately assess the capabilities of the current lagoons, both the hydraulic, nutrient and organic influent loads must be evaluated. This evaluation is presented in the following sections.

4.2.1.4.1 Hydraulic Capacity

The existing BWTP was constructed in 2004 with a 20-year design life. The record drawings and Design Report present the design average day, max day, peak hour and peak instantaneous flow rates for the plant. According to these documents the design average day flow rate is 903,000 gpd, the maximum day flow rate is 1,915,200 gpd and the peak hour and peak instantaneous flow rates are 2,697,120 gpd and 2,880,000 gpd, respectively. When compared to the existing flows discussed previously, the BWTP is roughly 85% of its hydraulic design capacity. This information is presented in Table 4-6.

Table 4-6 BWTP Design Capacity			
Flow Type	**Design Capacity (gpd)**	**Existing Influent Flow Rate[1] (gpd)**	**% of Design Capacity (%)**
Average Day	903,000	716,737	79.4%
Maximum Day	1,915,200	1,426,307	74.5%
Peak Hour	2,697,120	2,365,232	87.7%
Peak Instantaneous	2,880,000	3,003,128	104.3%
[1] Existing influent flow rates are conservatively based on available SCADA data. Based on recent meter verification, actual flow rates are likely less.			

4.2.1.4.2 Nutrient and Organic Capacity

The record drawings, design reports and O&M Manual define the design criteria for the influent BOD, TSS, TN and TP loading. These criteria are presented in Table 4-7.

Table 4-7 Design Treatment Plant Loading	
Contaminant	**Design Load**
Biological Oxygen Demand	2,100 lb/day
Total Suspended Solid	2,310 lb/day
Total Nitrogen	294 lb/day
Total Phosphorus	73.5 lb/day

Referencing the average day influent flow rates with the Energy Laboratory's monthly water quality reports, monthly average loading was calculated from November 2013 to October 2016. It was found that, although pollutant loads did exceed design conditions occasionally for TSS and TP, the pollutant loads did remain below design conditions for the majority of the period of record. TN loading, however, has exceeded design conditions for 25 of the 36 months of measurements, or nearly 70% of the time. Because of the previously discussed questionable influent meter reading, flow rates are believed to be high. This would cause calculated loading rates to be elevated. Chart 4-3 presents the total nitrogen loading data.

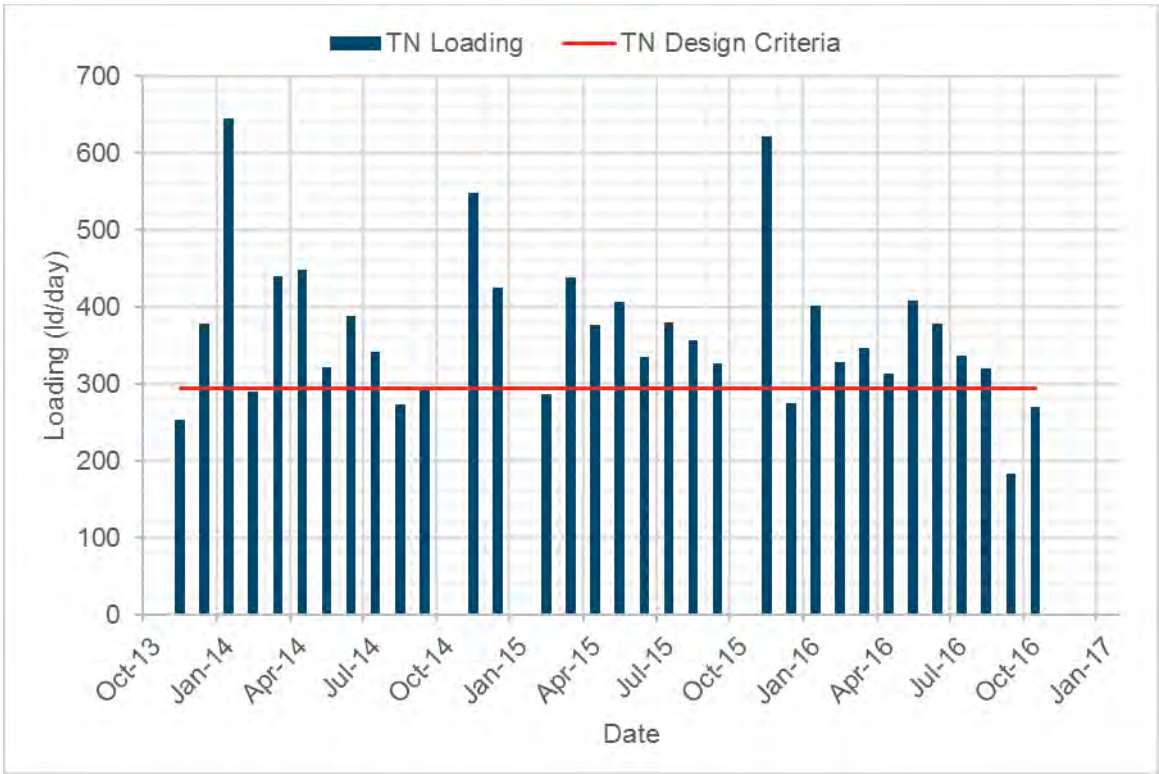


Chart 4-3: Total Nitrogen Influent Loading

Another factor critical to the performance of biological treatment lagoons is the influent BOD loading. Required oxygen transfer and mixing is largely dictated by the quantity of BOD entering the treatment plant. According to record drawings and the treatment plant's design report, the current BWTP was design BOD loading is 2,100 pounds per day (ppd). Influent flow rates and BOD concentrations were referenced from the City's monthly DMRs. This data suggests overall BOD loading has steadily increased over the life of the current permit. Large spikes in calculated monthly BOD loading have occurred periodically throughout the past 5 year, and have occurred more frequently in recent years. Since October of 2015, the calculated BOD loading has remained relatively consistently at or above the design loading value. Only three of the past 13 months have recorded BOD loading values noticeably below the design value. As with calculated TN loading, calculated BOD loading for recent years is expected to be elevated due to questionable influent meter readings. This information is illustrated in Chart 4-4. Remaining pollutant figures are available in Appendix 4.

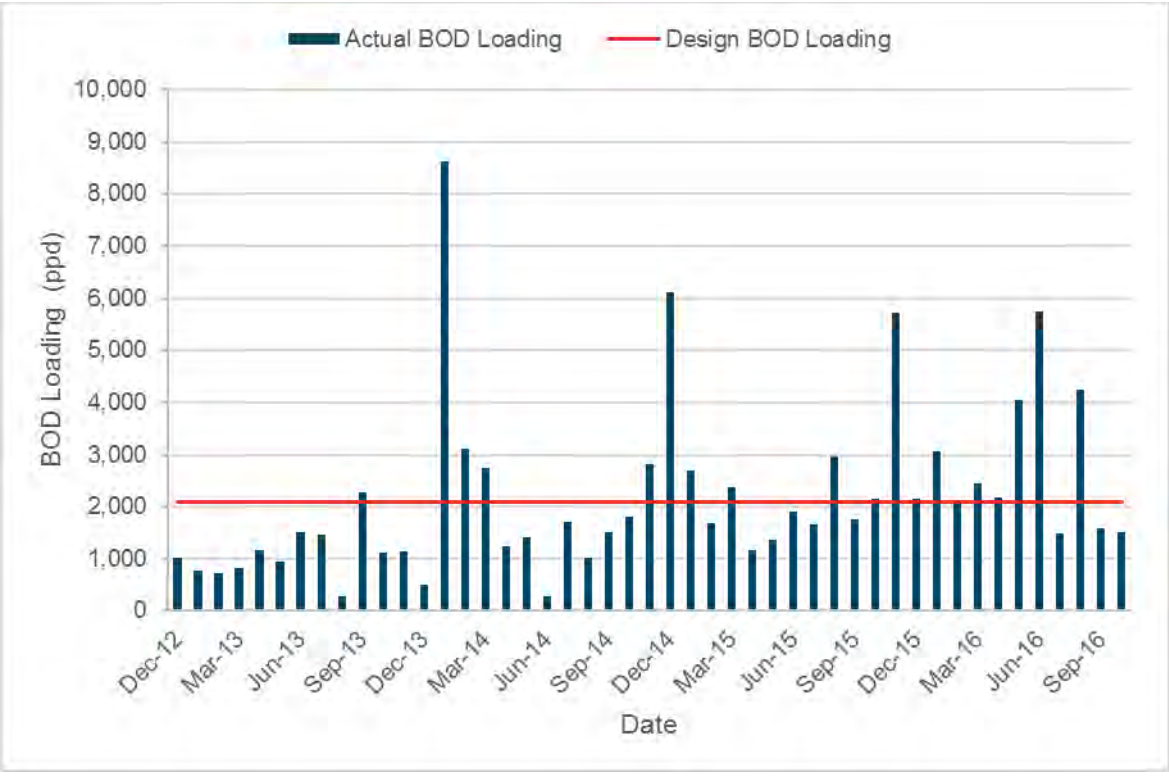


Chart 4-4: Treatment Plant Influent BOD Loading

Based on the lagoon capacity data, the BWTP has reached its design capacity. Upgrades to the treatment plant should be considered in the near future.

4.2.1.5 DEQ-2 Criteria

As previously discussed in Section 2.3.2.2, Circular DEQ-2 defines design standards for aerated lagoon systems with controlled discharge in Table 93-2. The existing system was reviewed against these standards; the findings are presented in Table 4-8.

Table 4-8
DEQ-2 Aerated Lagoon Design Standards vs Existing Conditions

Criteria	Circular DEQ-2 Standard	Existing Condition
Minimum Number of Cells	3	3
Depth	10-15 feet	10 to 19.25 feet
Minimum Detention Time Under Aeration	20 days	44.6 days
Maximum Seepage Rate	6 inches per year	requires verification to confirm
Indicates the existing condition is not in compliance with DEQ-2 standard		

Aerated lagoons with controlled discharge are required to have at least 3 cells with minimum depths of 10-15 feet. The BWTP has 3 cells, two treatment and one storage. The treatment cells both have an operating depth of 10 feet while the storage lagoon has an operating depth of 19.25 feet. The minimum detention time under aeration is 20 days. The two treatment lagoons each have an operating capacity of 16 MG, or 32 MG combined. The existing average day flow was calculated at 717,000 gpd in Section

4.1.1.1. Therefore, the existing detention time in the treatment cells is 44.6 days. As such the number of cells, cell depths and detention times are all compliant with DEQ-2 standards.

Circular DEQ-2 only permits 6 inches per year of seepage. A field test would be required to confirm leakage rate. Because of limited accuracy on influent data, a reliable estimate of leakage cannot be made at this time.

4.2.2 Piping, Pumps and Control Structures

A piping system consisting of various valve vaults and control structures to direct flow throughout the BWTP. Distribution, bypass, transfer and recycle pipelines are all utilized to convey wastewater within the treatment plant. Additionally, outlet and overflow piping are included. The pipelines and control structures are detailed in the sections to follow. The existing pipelines are illustrated in Figure 4-1.

4.2.2.1 Distribution Piping

The plant's distribution piping includes approximately 450 LF of PVC sewer main ranging in size from 15- to 21-inch and runs north-south along the dike east of Lagoon #1. The distribution main receives wastewater from the diversion vault on the outfall sewer and discharges to Lagoon #1. Components of the pipeline are summarized in Table 4-9.

Table 4-9
Distribution Piping Components

Pipeline	
15-inch PVC	137 LF
18-inch PVC	137 LF
21-inch PVC	170 LF
Valve Vault No. 1	
Structure	72-inch Pre-Cast Concrete Manhole
Inlet	21-inch PVC (south) 8-inch DI (west)
Outlet	12-inch DI (east) 18-inch PVC (north)
Valves	(1) Swing Gate
Valve Vault No. 2	
Structure	72-inch Pre-Cast Concrete Manhole
Inlet	18-inch PVC (south)
Outlet	12-inch DI (east) 15-inch PVC (north)
Valves	(1) Swing Gate

Table 4-9 (cont.) Distribution Piping Components	
Valve Vault No. 3	
Structure	48-inch Precast Concrete Manhole
Inlet	15-inch PVC (south) 4-inch PVC (north)
Outlet	12-inch DI (east)
Valves	none

Three valve vaults exist along the distribution main. Valve Vault No. 1 is the southernmost vault and receives wastewater directly from the diversion vault as well as from the recycle pipeline discussed later. It is a 72-inch precast concrete manhole with rim access and steps. Valve Vault No. 2 is connected to Valve Vault No. 1 by approximately 137 LF of 18-inch PVC sewer main; it is a 72-inch concrete manhole with steps and manhole rim access. Valve Vault No. 3 is the northernmost vault on the distribution pipe and receives raw wastewater from the upstream distribution main as well as the pump building's 4-inch sanitary sewer connection. Valve Vault No. 3 is connected to Valve Vault No. 2 by roughly 137 LF of 15-inch PVC pipe. It is a 48-inch concrete structure with manhole rim access and steps. Each of valve vaults are linearly connected with the distribution pipeline and discharge to Lagoon #1 through 12-inch ductile iron (DI) pipes. Swing gates are present in Valve Vault No. 1 and No. 2 to manually direct the wastewater.

4.2.2.2 Bypass Piping

The BWTP bypass pipeline consists of roughly 920 LF of 21-inch PVC pipe and connects the diversion vault on the outfall sewer to Lagoon #2. The bypass pipeline runs east-west along the plant's southernmost dike for roughly 620 LF, then turns and jogs north along the dike separating Lagoons #1 and #2. This pipeline is employed when the plant is operated in parallel or when Lagoon #1 is to be bypassed. Valve Vault No. 4 is included on the bypass pipeline. It is a 48-inch precast concrete manhole with rim access and concrete steps. Wastewater enters the vault through the pipeline and is discharged to Lagoon #2 though a 12-inch DI pipe.

4.2.2.3 Transfer Lines

Four pipelines, Transfer Lines A, B, C and D, were constructed to transport wastewater throughout the plant. Transfer lines B and C each have a series of control structures to direct the flow. Transfer piping and control structures are summarized in Table 4-10 and 4-11.

Table 4-10 Transfer Line Piping	
Transfer Line A	
16-inch PVC	1,273 LF
Transfer Line B	
12-inch PVC	274 LF
16-inch PVC	486 LF
Transfer Line C	
12-inch PVC	274 LF
16-inch PVC	170 LF
Transfer Line D	
12-inch PVC	1,569 LF

Table 4-11 Transfer Line Control Structures	
Control Structure 1 (CS1)- Transfer Line C	
Structure	72-inch Pre-Cast Concrete Manhole
Inlets	12-inch DI (west)
Outlets	12-inch DI (east) 12-inch PVC (north)
Valves	(3) Gate Valves
Control Structure 2 (CS2)- Transfer Line C	
Structure	72-inch Pre-Cast Concrete Manhole
Inlets	12-inch PVC (south) 12-inch DI (west)
Outlets	12-inch DI (east) 12-inch DI (north)
Valves	(4) Gate Valves
Other	Level Transducer
Control Structure 3 (CS3)- Transfer Line C	
Structure	84-inch Pre-Cast Concrete Manhole
Inlets	12-inch PVC (south) 12-inch DI (west)
Outlets	12-inch DI (east) 16-inch PVC (north)
Valves	(3) Gate Valves (1) Butterfly Valve (1) Mud Valve

Table 4-11 (cont.) Transfer Line Control Structures	
Control Structure 4 (CS4)- Transfer Line B	
Structure	72-inch Pre-Cast Concrete Manhole
Inlets	(2) 12-inch DI (west)
Outlets	12-inch PVC (north)
Valves	(3) Gate Valves
Control Structure 5 (CS5)- Transfer Line B	
Structure	72-inch Pre-Cast Concrete Manhole
Inlets	(2) 12-inch DI (west) 12-inch PVC (south)
Outlets	12-inch PVC (north)
Valves	(4) Gate Valves
Control Structure 6 (CS6)- Transfer Line B	
Structure	84-inch Pre-Cast Concrete Manhole
Inlets	(2) 12-inch DI (west) 12-inch PVC (south)
Outlets	16-inch PVC (north)
Valves	(3) Gate Valves (1) Butterfly Valve (1) Mud Valve
Control Structure 7 (CS7)-Transfer Line B and D	
Structure	60-inch Pre-Cast Concrete Manhole
Inlets	16-inch PVC (south) 12-inch PVC (southwest)
Outlets	16-inch DI (west)
Valves	(1) Gate Valve

- Transfer Line A

  Transfer Line A is roughly 1,300 LF of 16-inch PVC and runs east-west along the dike separating the treatment lagoons from the storage lagoon. It is required when gravity flow is not possible between the treatment and storage lagoons. Transfer Line A will convey wastewater from Line B to the pump house when water levels within the lagoons prevent gravity flow. Additionally, when the plant is operated in parallel, wastewater may be discharged to Line A if water levels within the control structures exceed acceptable levels.

- Transfer Line B

  Transfer Line B runs along the eastern edge of the BWTP and connects Lagoon #2 to Lagoon #3. The southern section of the pipeline is roughly 275 LF of 12-inch PVC with 3 control structures. Control Structure 4 (CS4) is the

southernmost control structure; Control Structure 5 (CS5) is 137 LF north of CS4. CS4 and CS5 are both 72-inch concrete structures with 24-inch manhole rim access covers and steps provided. Control Structure 6 (CS6) is a 137 LF north of CS5. It is an 84-inch pre-cast concrete manhole with steps and rim access. Each structure has two 12-inch DI inlets with gate valves. The two inlet pipes have been installed at different elevations to allow the City to control Lagoon #2 draw off levels. All control structures have gate valves included on all inlet and outlet piping to allow for manual control of flow, apart from CS6. The outlet piping on CS6 includes a butterfly and a mud valve. The mud valve is 10.7 feet above the bottom of the structure. It is closed for all flow patterns except when the plant is operated in parallel with gravity flow from Lagoons #2 to #3. The mud valve is open while the butterfly valve is closed. The mud valve acts as a spillway and controls flow to Lagoon #3.

When water levels within the lagoons allow for gravity flow, the wastewater travels though the northern portion of Transfer Line B. This includes roughly 500 LF of 16-inch PVC pipe to Control Structure 7 (CS7). CS7 is a 60-inch precast concrete manhole with step and rim access an accepts wastewater from Lines D and B and discharges to Lagoon #3 through a 16-inch DI pipe. A 16-inch buried gate valve is installed on Transfer Line B upstream on CS7. When the water level is too high in Lagoon #3 to allow for gravity flow, Transfer Line B discharges to Line A, as previously discussed.

- Transfer Line C

  Transfer Line C runs north-south along the dike separating the two treatment lagoons. Roughly 275 LF of 12-inch PVC, 170 LF of 16-inch PVC and 3 control structures are included in Transfer Line C. Control Structure 1 (CS1) is the southernmost. Both Control Structure 2 (CS2) and CS1 are 72-inch concrete structures with 24-inch manhole rim access and steps included. Control Structure 3 (CS3) is the northern most structure on Line C. It is an 84-inch pre-cast concrete manhole with rim access and steps. The 3 control structures are linearly connected to each other with a 12-inch PVC pipe. Wastewater from Lagoon #1 flows into each control structure though a 12-inch DI pipe. The control structures discharge to Lagoon #2 through 12-inch DI pipes. Gate valves are included in each control structure to direct flow, CS3 includes a mud valve and a butterfly valve on the outlet pipe. Similar to CS6 on Transfer Line B, the mud valve is 10.7 feet above the bottom of the control structure. When the plant is operated in series with gravity flow to Lagoon #3, the mud valve is open and acts as an emergency overflow. For all other flow patterns, the mud valve is closed. Per the record drawings, CS2 includes a level transducer to measures water level in Lagoons #1 and #2. However, as previously mentioned this transducer is no longer functioning.

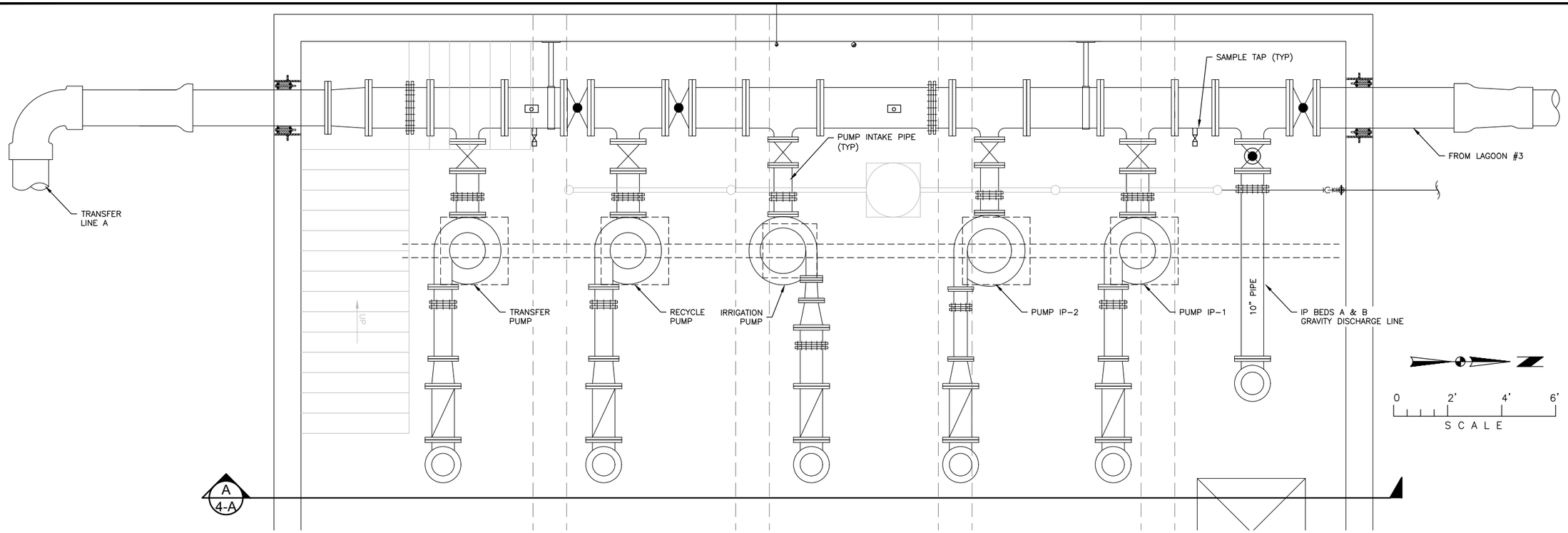
- Transfer Line D

  Transfer Line D is roughly 1,600 LF of 12-inch PVC and runs parallel to Line A. It conveys wastewater from the pump building to Lagoon #3. It is operated when the water level within the storage lagoon nears or exceeds water levels in the treatment lagoons and gravity flow is no longer available. The transfer pump, housed in the pump building, has a capacity of 1,330 gpm at 17 feet of total dynamic head (TDH). The piping and pumps included in the pump house are

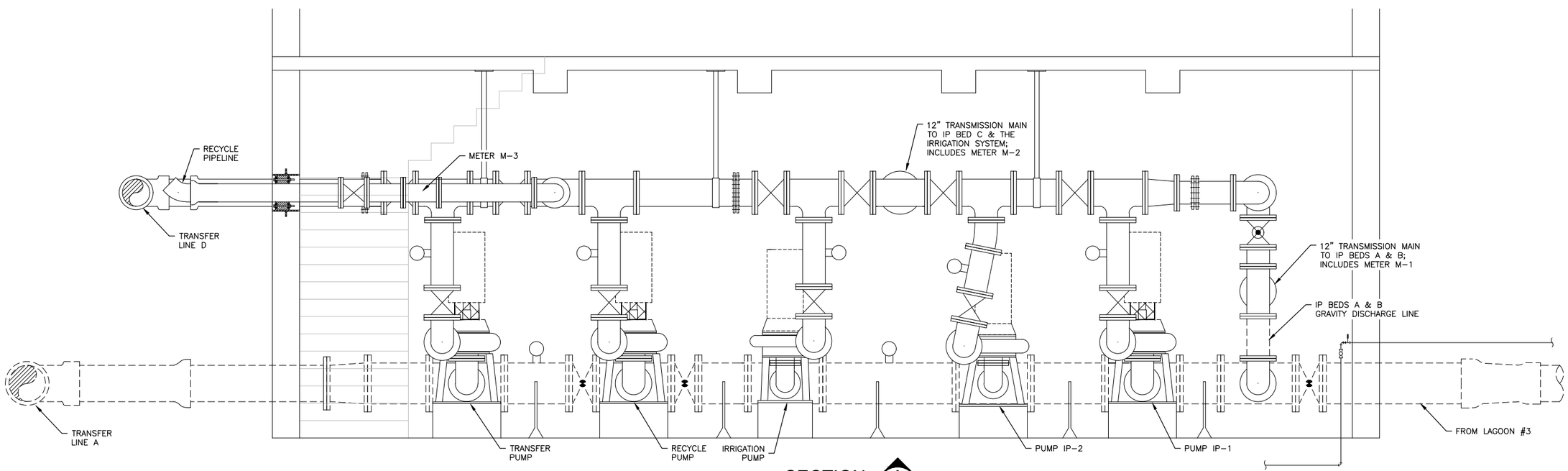
shown in Figure 4-2.

4.2.2.4 Recycle Piping

Roughly 470 LF of 8-inch PVC exists in the BWTP as a recycle line. The recycle line conveys treated wastewater from the pump house to the beginning of the plant and includes a magnetic flow meter M-3. According to the 2004 Operations and Maintenance Manual, the recycle pipeline is to be used when the concentration of nitrate in the effluent exceeds 4 mg/l. The recycle pipeline discharges to Valve Vault No. 1, on the distribution pipeline. A recycle pump, with a capacity of 1,330 gpm at 17 feet of TDH, is located in the pump house. The recycle pump discharges to the recycle pipeline. It may also be used as a backup to the transfer pump when necessary. Refer to Figure 4-2 for the pump house pumps and piping schematic.



LOWER LEVEL PIPING



SECTION A 4-A

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DRAWN BY: CJS
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QUALITY CHECK:
DATE: 04/20/2017
JOB NO. B16-048
FIELDBOOK

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

BWTP PIPING AND PUMPS

FIG 4-2.DWG
FIGURE 4-2

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 4-2.dwg, 4/28/2017 1:41:30 PM, cjs

4.2.2.5 Outlet Line

The outlet pipe is roughly 400 LF of 16-inch PVC. It conveys treated wastewater from the discharge screens in Lagoon #3 to the pump building. From there, the treated water is pumped to one of the two disposal options, discussed later in this chapter, or to the recycle pipeline.

4.2.2.6 Overflow Piping

Three overflow pipes exist in the BWTP. An 18-inch DI pipe intersects the dike separating Lagoons #1 and #2 and is at an elevation at 4412.00 feet, or 11.35 feet above the bottom of Lagoon #1 and 11.55 feet above the bottom of Lagoon #2. The operating depth of Lagoons #1 and #2 are 1.1 feet below the overflow pipe. The top of the dike is at an elevation of 4418.25 feet, 6.25 feet above the overflow piping.

A second overflow is in the southern dike of Lagoon #2. It is an 18-inch DI pipe at an elevation of 4414.00 feet. This is 13.55 feet above the bottom of Lagoon #2, 3.1 feet above the operating depth and 4.25 feet below the top of the dike.

The final overflow piping is an 18-inch DI pipe intersecting Lagoon #3's northern dike. The inlet of the pipe has an invert elevation of 4415.25 feet. The elevation of the overflow piping is equal to the maximum allowable water surface elevation in Lagoon #3; it is 19.25 feet above the bottom of the Lagoon #3 and 3.00 feet below the top of the dike. Lagoon #3 emergency overflow discharges to IP Bed A at an elevation of 4404.00 feet. Overflow piping elevations are summarized in Table 4-12.

Table 4-12
Overflow Piping

	Elevation
Lagoon #1	
Bottom of Lagoon #1	4,400.65
Lagoon #1 Water Surface	4,410.90
Lagoon #1 Overflow	4,412.00
Top of Dike	4,418.25
Lagoon #2	
Bottom of Lagoon #2	4,400.45
Lagoon #2 Water Surface	4,410.90
Lagoon #2 Overflow	4,414.00
Top of Dike	4,418.25
Lagoon #3	
Bottom of Lagoon #3	4396.00
Lagoon #3 Water Surface	4415.25
Lagoon #3 Overflow	4415.25
Top of Dike	4418.25

4.2.2.7 Pumps and Piping Conditions

Conversations with City staff and visual inspection indicate the BWTP's piping and control structures are in generally good condition. No issues associated with the valve vaults, pumps or piping have been reported. The only concern regarding the condition of the existing piping structure was reported in a March 21, 2017 e-mail. According to the City of Belgrade, treatment lagoon's level transducer is not functioning properly. As such, the City is unable to accurately measure the water depth in the treatment lagoons. Plant operator Mr. Paul Burkardt, has described maintenance issues associated with the transducer unit being located within the control structure. It was suggested that moving the unit out the manhole would alleviate some of the maintenance frustrations.

4.2.2.8 Pumps and Piping Capacity

The hydraulic capacity of the existing interpond piping is discussed in the following sections. Manning's equation was utilized to assess the capacity of pipeline where open channel flow is assumed. For pipelines that are considered low head systems were evaluated using the energy equation. All existing pipeline capacity calculations are available in Appendix 4.

- Distribution Piping

  The BWTP distribution piping is roughly 450 feet of gravity main. The downstream portion is a 21-inch PVC pipe is laid at a 0.10% slope. The main transitions to smaller diameter pipe at each valve vault. First to an 18-inch PVC and later a 15-inch PVC pipe, both laid at 0.20% slopes. Assuming open channel flow at 85% pipe depth and a Manning's n value of 0.001, the Federal Highway Administration's (FHWA)s Hydraulic toolbox calculates the capacity of the downstream portion of the distribution piping at 6.102 cfs (3.94 MGD). The 18-inch and 15--inch segments' capacities are 5.721 cfs (3.70 MGD) and 3.512 cfs (2.27 MGD), respectively. The current peak hour flow is approximately 2.37 MGD. The current distribution pipeline has more than sufficient capacity to handle the existing flows.

- Bypass Piping

  The Bypass pipeline is a 21-inch PVC main laid at a minimum slope of 0.10%. Assuming open channel flow, a Manning's n value of 0.011 and 85% flow depth, the minimum capacity of the bypass pipeline is 6.10 cfs (3.49 MGD). Sections with greater slopes will have larger capacity. The current peak hour and peak instantaneous flows are estimated at 2.37 MGD and 3.00 MGD, respectively. The Bypass Pipeline has sufficient capacity to handle the existing flows.

- Transfer Line B

  The southern portion of Transfer Line B is a 12-inch PVC laid at a 0.00% slope used to control water level and flow from Lagoon #2. The northern portion of Line B is 16-inch PVC pipe installed to transport wastewater from Lagoon #2 to Lagoon #3 and is considered a low head system. The maximum water surface elevation of Lagoon #2 is 4410.9 ft. Assuming the water surface elevation in Lagoon #3 is 4410.8, Transfer Line B's hydraulic capacity is 650,898 gpd. As the water level in Lagoon #3 decreases, the capacity of pipeline increases. The

capacity of Line B exceeds the existing peak hour flow when the water surface elevation in Lagoon #3 is 4409.69 ft. If the water level in Lagoon #3 exceeds the water level in Lagoon #2, gravity flow is no longer available and the treated wastewater will flow through Transfer Line A to the pump house.

- Transfer Line C

  The southern portion of Transfer Line C is a 12-inch PVC laid at a 0.00% slope used to control water level and flow between the treatment ponds. The northern portion Line C is a 16-inch PVC laid at a 0.97% slope and used to convey wastewater to Line A. The FHWA Hydraulic toolbox calculates the capacity of this main at 9.203 cfs (5.95 MGD), assuming open channel flow, Manning's n of 0.011 and 85% pipe depth. This is nearly 2 times greater than the peak instantaneous flow of 3.00 MGD.

- Transfer Lines A and D

  Transfer Line A is used in conjunction with Line D and the transfer pump to convey wastewater to Lagoon #3 when gravity flow is not available. To assess the capacity of the existing pipelines and transfer pump, pump run times for the transfer pump were downloaded from City's SCADA system. Records indicate the transfer pump has reported run times greater than 0.0 hr/day for only 3 months from January 2010 to October 2016. Those months were July 2010, August 2011 and May 2014. This indicates water levels in the storage lagoon rarely exceed elevations that restrict gravity flow. As such, Transfer Lines A and D are rarely needed. The design capacity of the Transfer pump is 1,330 gpm, or 1.92 MGD. This exceeds current the current maximum day flow rate. The transfer pump run time figures are available in Appendix 4.

- Recycle Piping

  To test the efficiency of the recycle pump, the pump's nominal capacity of 1,330 gpm was used to convert average pump run times reported by the SCADA system to average flow rates. The measured flow rates in the SCADA system were compared to the calculated rates. This comparison is presented in Chart 4-5. Detailed calculations are available in Appendix 4.

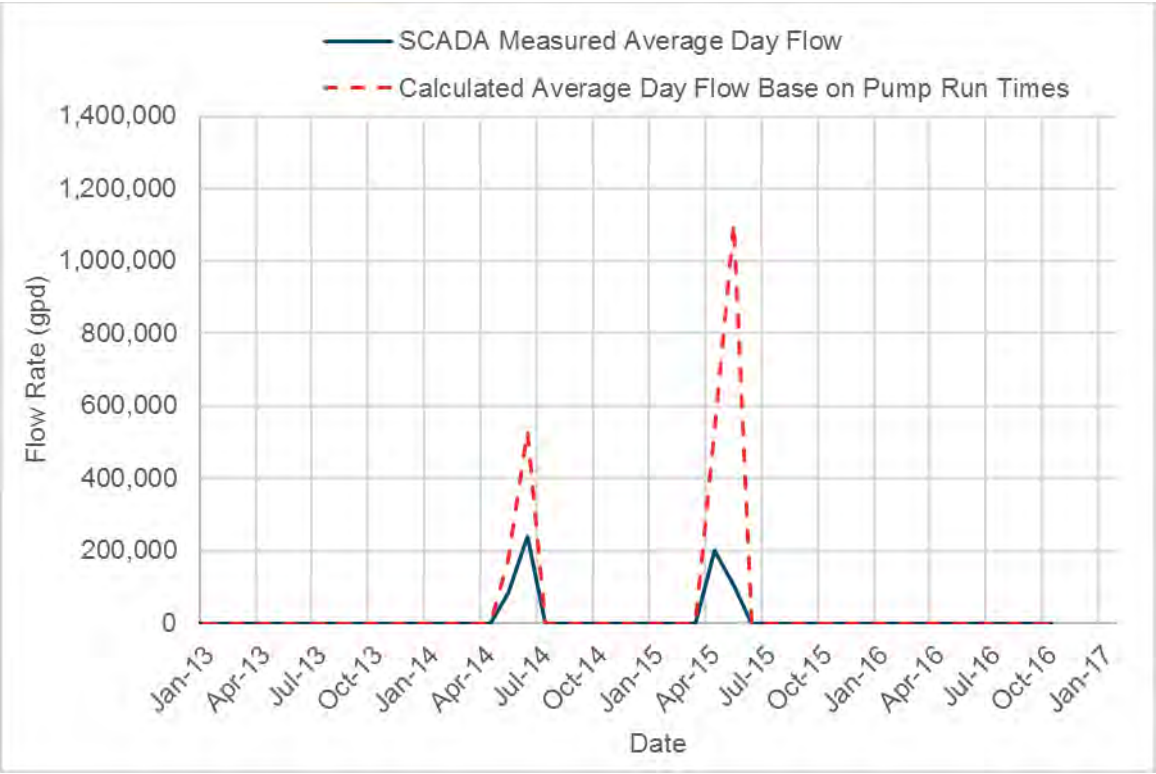


Chart 4-5: Average Recycle Flow Rate

Measured flow through the recycle pipeline occurs simultaneously with measured pump run times. This indicates the recycle pump has not been needed as a backup for the transfer pump in recent years. However, average flow rates calculated based on average pump run times are considerably larger than measured average flow rates. This indicates the pump is not running as efficiently as designed. The decrease from expected efficiency may be due to additional head loss in the recycle line. Depending on the shape of the pump curve, this could have a significant impact on the actual flow rate. Addition head loss may be caused by, but not limited to additional fittings, partially open valve or solids deposition in the pipeline.

Additionally, the 2004 Operations and Maintenance Manual suggests running the recycle pump continuously whenever nitrate effluent concentrations exceed 4 mg/l. According the water quality data received from Energy Laboratories, Inc. nitrate concentrations in the effluent have consistently exceeded 4 mg/l in the warmer months, June to September, from 2014 to 2016. Average pump run times show the pump was operated between April and June of 2014 and 2015, and was not operated at any time in 2016. This information is presented in Chart 4-6.

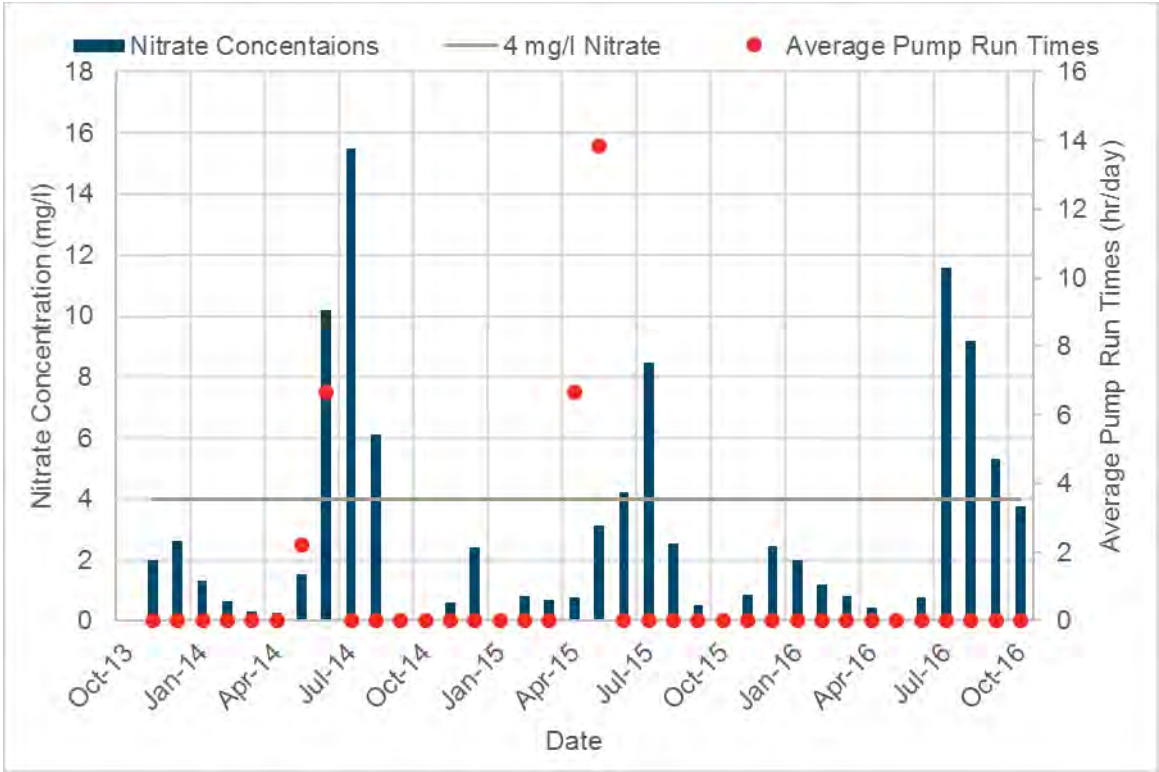


Chart 4-6: Recycle Pump Runtimes vs Effluent Nitrate Concentrations

4.2.2.9 DEQ-2 Piping and Control Structure Criteria

Section 93.44 of Circular DEQ-2 describes the minimum piping and control structure requirements for treatment pond design. Per DEQ-2 design standards, treatment ponds must contain a series of control structures for water level and flow control. The structures must be constructed of non-corrodible materials and located to minimize short circuiting. They must be accessible for maintenance with adequate ventilation for safety. Additionally, City staff must be able to lock control structures to prevent vandalism.

The existing control structures are all pre-cast concrete manholes with rim and step access. The structures are located along the dikes running north-south to control the flow and water levels within the ponds and provide several inlet and outlet locations to minimize short circuiting in the treatment process. Only one inlet and outlet structure serve Lagoon #3. However, due to the controlled discharge with the aerators included in the pond, short circuiting is not believed to be a problem.

All piping must be either ductile iron or PVC. For ponds large enough to encounter stratification, like the BWTP, DEQ-2 requires multiple outlet pipes at varying elevations; three outlet pipes are recommended. For irrigation storage ponds, multiple outlet elevations are also recommended. The bottom pipe must be 10-feet from the toe of the dike, 1 foot above the bottom of the pond and must employ a vertical withdrawal. Biological treatment ponds must also be equipped with overflow piping capable of conveying the peak instantaneous flow.

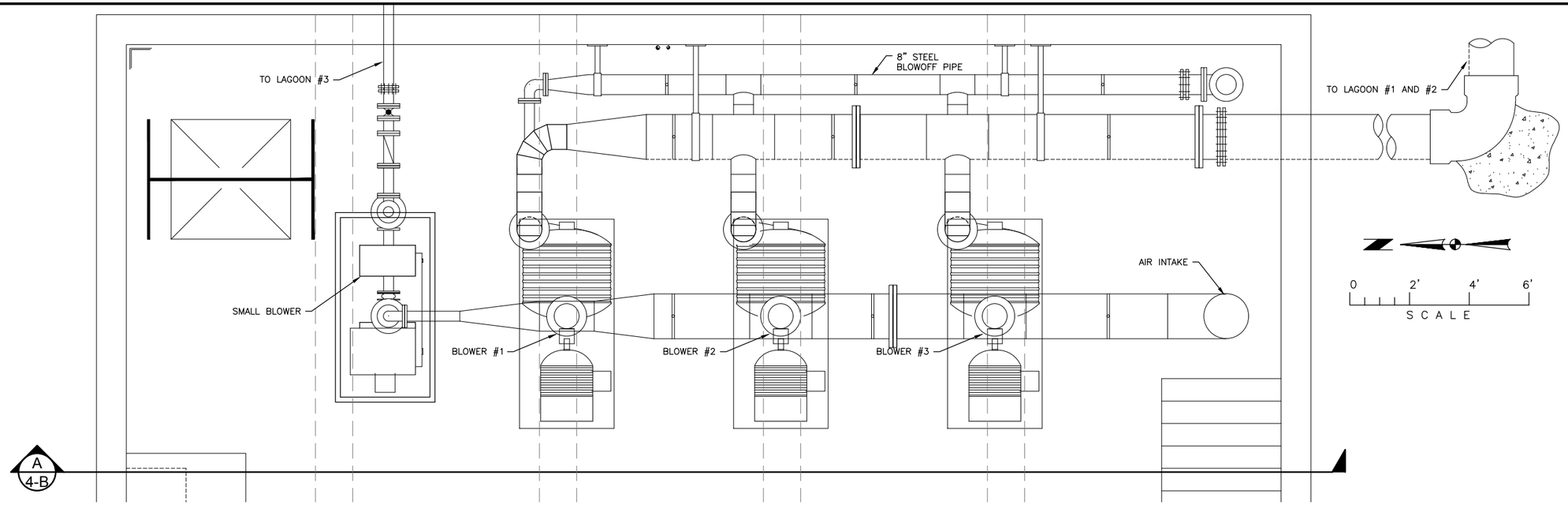
The BWTP includes only DI and PVC piping to convey wastewater. Two pipes, at varying elevations, control draw off levels in Lagoon #2; this feature is not available in

Lagoon #1 however. The discharge pipe from Lagoon #3 has two intake screens with vertical withdrawal. Per the record drawings, the inverts the discharge screens are 9 inches above the bottom of the pond; the top of the screens are 27 inches from the pond bottom. The eastern screen is only 4 feet from the toe of the dike and the west screen is 10 feet from the dike. The treatment pond overflow piping has a 0.0% slope. The storage lagoon's overflow pipe has a slope of 10.2%, Calculations applying the FHWA Hydraulic toolbox with an 85% pipe depth and a Manning's n of 0.011 indicate the capacity of storage overflow at 8.518 cfs (5.5 MGD). The existing plant's peak instantaneous flow is 3.00 MGD. The treatment lagoon overflow piping does not have sufficient capacity to handle the peak instantaneous flow rate; however, the storage lagoons piping is more than sufficient.

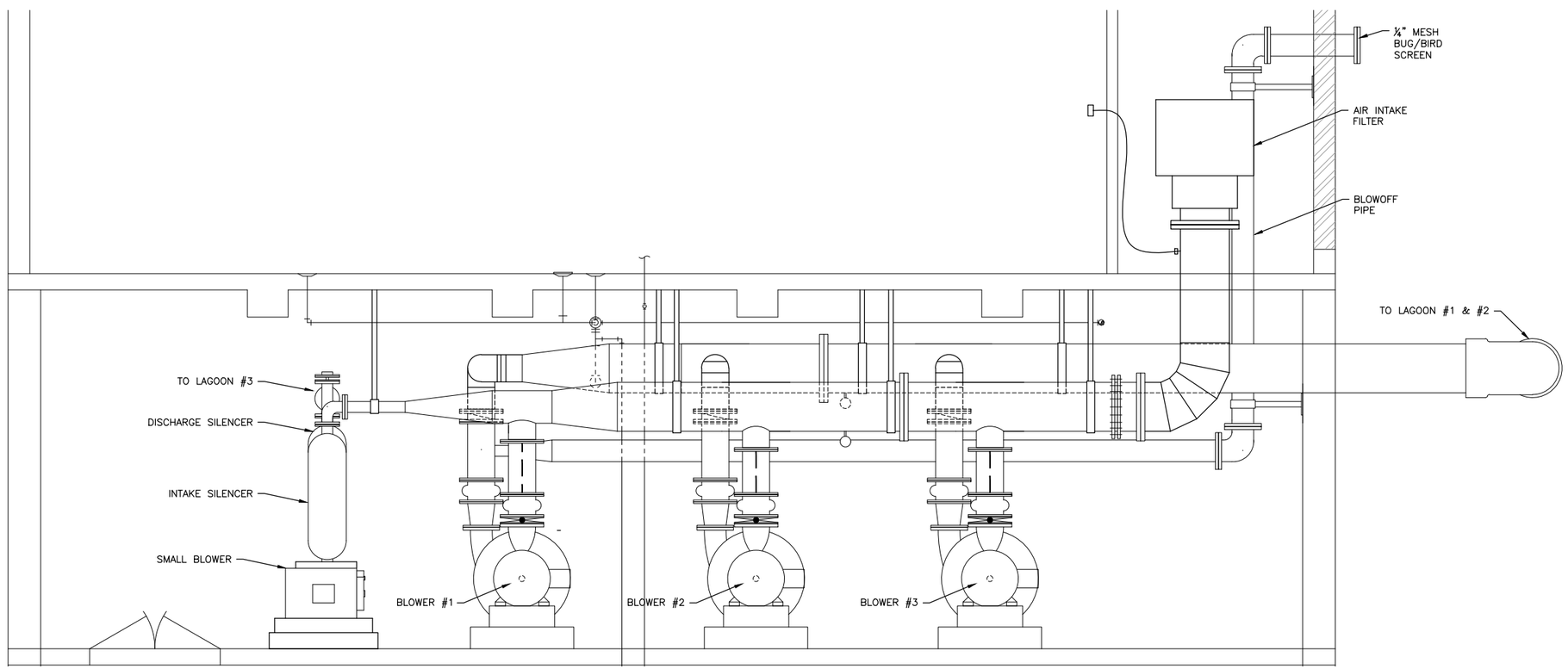
Although the existing plant's piping and controls do not meet all of DEQ-2's design standards. These issues are not considered to be largely impacting the efficiency of the treatment system and immediate action is not believed to be necessary.

4.2.3 Aeration System

As previously mentioned, the BWTP is a partially aerated lagoon system. Air is pumped into the lagoons to provide both mixing and the required oxygen to sustain aerobic digestion. Lagoons #1 and #2 are considered the treatment lagoons; Lagoon #3 is the storage and polishing lagoon. Oxygen is introduced into each pond through a series of static tube and surface aerators. Blowers located in the pump house supply oxygen to the static tube aerators in the treatment ponds and the coarse bubble diffusers in the storage lagoon. The blower configuration is illustrated in Figure 4-3. The following sections detail the components of the BWTP aeration system. Tables 4-13 and 4-14 summarize the aeration system; a schematic of the system is shown in Figure 4-4.



FLOOR PLAN



SECTION A 4-B

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DRAWN BY: CJS
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QUALITY CHECK:
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JOB NO. B16-048
FIELDBOOK

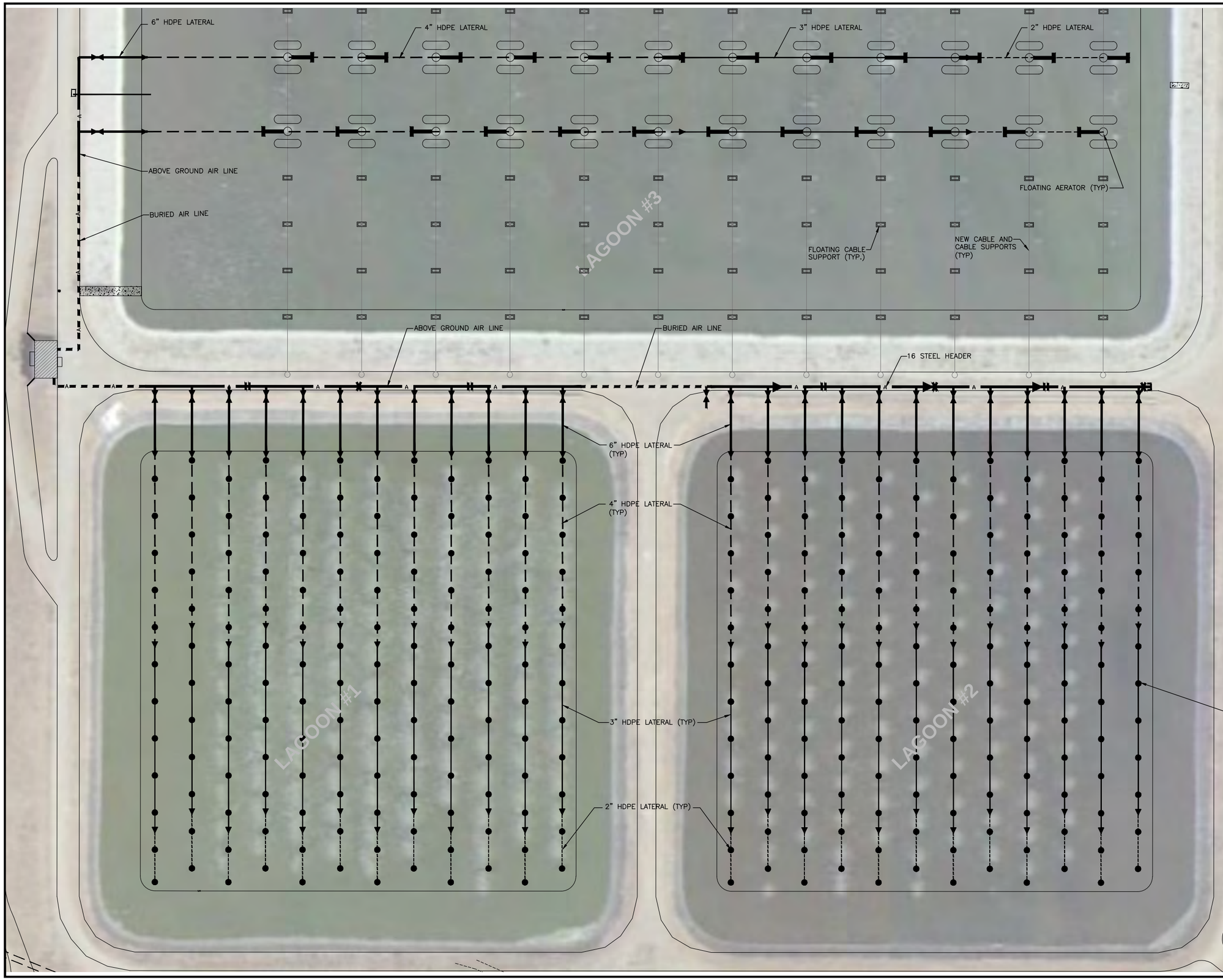
BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

BWTP BLOWERS

FIG 4-3.DWG

FIGURE 4-3

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 4-3.dwg, 4/28/2017 1:46:02 PM, cjs



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BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

AERATION SYSTEM

FIG 4-4.DWG

FIGURE **4-4**

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 4-4.dwg, 4/28/2017 1:57:05 PM, cjs

4.2.3.1 Treatment Lagoon.

Table 4-13 Treatment Lagoons' Aeration System	
Blowers	
Number	3
Type	Centrifugal
Motor (each)	100 HP
Capacity (each)	2,160 cfm
Header Pipe	
Length (total)	1,175 LF
Size	10- to 18-Inch
Materials	Above-Ground Steel Buried DI
Lateral Pipes	
Number (per pond)	12
Length per lateral	550
Size	2- to 6-Inch
Material	HDPE
Aerators	
Number (per pond)	144
Type	Static Tube

Each of the two treatment lagoons has 12 laterals running north-south along the pond bottom. There are 12 static tube aerators on each lateral, totaling 144 aerators in each treatment lagoon. The 6-foot high aerators are configured in a grid pattern to maximize mixing. The aerators breakdown the air supply into course bubbles to provide oxygen transfer .

The laterals along the bottom of the lagoons are roughly 550 LF long, HDPE pipe. The northern segment of each lateral is 6-inch pipe. As the lateral extends the length of the lagoon, it decreases in size to a 2-inch pipe at the southern end. The laterals are fed by a header pipe running roughly 1,175 LF east-west along the plant's center dike. The header pipe ranges in size from 10- to 18-inches and is primarily above ground steel pipe, while the rest is buried DI. Twenty-four shut-off/throttling valves are installed along the header pipe, one for each lateral.

Three centrifugal blowers are housed on the mid level of the pump house and are illustrated in Figure 4-3. Each blower has a 100 HP motor, is rated at 2,160 cfm for a discharge pressure of 6.0 psi and is equipped with a control panel to provide limited local control. One intake filter with a ¼-inch mesh screen supplies air to all blowers. The treatment system was designed to function properly with two blowers running. The third provides redundancy, however may be necessary as the plant nears its design capacity.

4.2.3.2 Storage Lagoon

Table 4-14 Storage Lagoon Aeration System	
Blowers	
Number	1
Type	Rotary Positive Displacement
Motor	50 HP
Capacity	428 cfm
Header Pipe	
Length	275 LF
Size	6-inch
Materials	Above-Ground Steel Buried DI
Lateral Pipes	
Number	2
Length per lateral	1,100
Size	2- to 6-Inch
Material	HDPE
Aerators	
Number	24
Type	Surface

Surface aerators are installed in the storage lagoon to provide additional treatment as well as mitigate issues associated with odor. Twenty-four floating surface aerators run the length of the storage pond in two rows. Twelve support cables have been installed perpendicular to the laterals. Two HDPE laterals, ranging in size from 2- to 6-inches, run the length of the storage lagoon. Four small orifices have been drilled into the pipes under each floating aerator. The orifices are to act as coarse bubble diffusers and prevent icing around the surface aerators.

A positive displacement blower, known as the small blower and shown in Figure 4-3, is housed in the pump house. It draws air from the same intake filter as the larger blowers. The small blower is powered by a 50 HP motor and is rated at 428 cfm. This blower supplies air to the storage lagoon laterals though a header pipe consisting of buried 6-inch DI and above ground 6-inch steel pipe.

4.2.3.3 Aeration System Conditions

A number of issues with the BWTP's aeration system were noted during a site visit performed by TD&H Engineering in October 2016. Multiple static tube aerators were spotted floating on the surface of the treatment lagoons. It was also reported that the airline in the storage lagoon is floating and approximately half of Lagoon #3's floating aerators are not functional. The floating aerators have been high maintenance and

prone to electrical damage. In addition the cable and floating support system is not currently performing as intended. Many of the cable supports were upside down. The gas spring system which is supposed to allow for slack to be automatically released as the water level drops may not be functioning properly and causing the floats to flip upside down. The floating airline can be seen in Photo 4-2. Notes and additional photographs from the October 2016 site visit are included in Appendix 4.

Photo 4-2: Storage Lagoon Floating Airline

4.2.3.4 Aeration System Capacity

4.2.3.4.1 Treatment Lagoons

The aeration system was designed to have two of the large blowers operating simultaneously under normal conditions. The City's SCADA system records run times for each of the three large blowers that supply air to the treatment lagoons. Nearly 5 years of data, from January 1, 2012 to October 31, 2016, was reviewed to assess the efficiency of the current aeration system. For the past five years, the City has been running 2 of the 3 large blowers continuously. Run times for the three large blowers are presented in Chart 4-7.

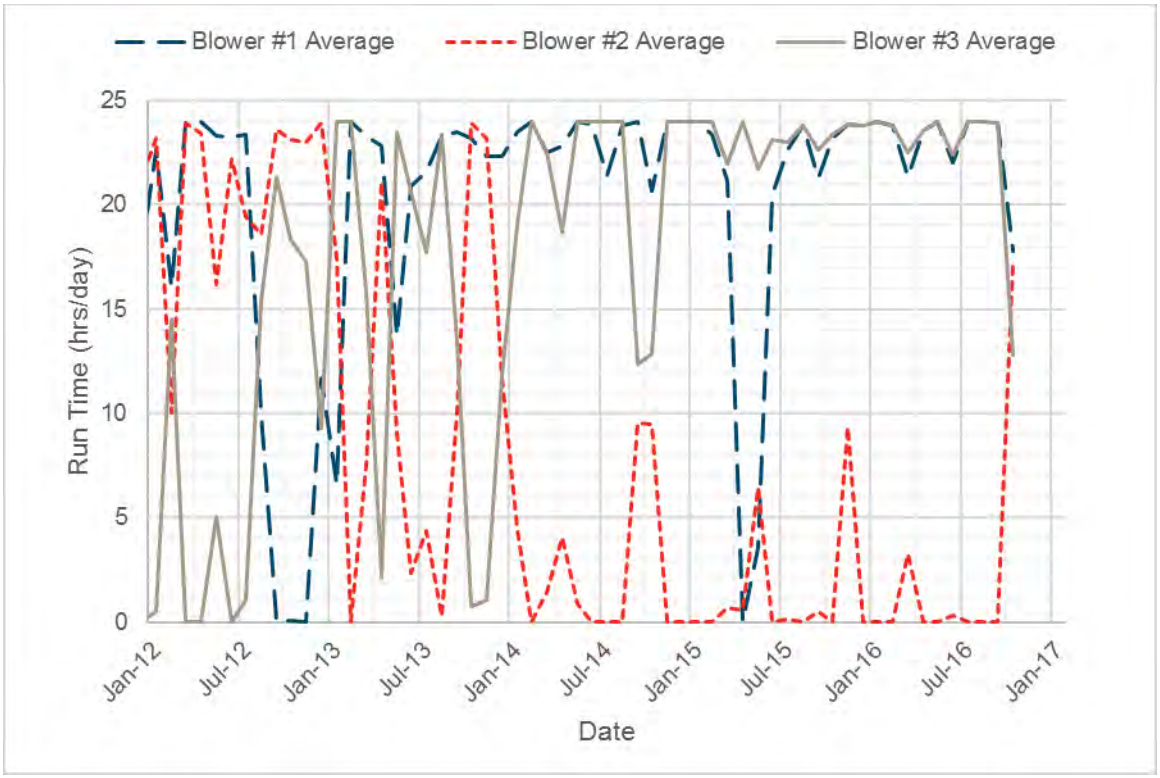


Chart 4-7: Treatment Lagoon Blowers' Average Run Times

At the DEQ's request, an inspection of the BWTP was performed on July 20, 2015 by H&S Environmental, LLC. During the field inspection, dissolved oxygen (DO) concentrations were collected at 9:00 am in Lagoon #1; concentrations ranged from 0.01 mg/l to 0.40 mg/l. The relatively low DO concentrations recorded in the morning indicates portions of the BWTP experiences anaerobic conditions throughout the evening and early morning. The bacteria used for the nitrification of ammonia require oxygen to thrive. As such, anaerobic conditions decrease the efficiency of the treatment plant. DO measurements were taken again in the afternoon, and concentrations had lifted to just over 1 mg/l. In order to ensure constant aerobic conditions and improve the efficiency of aeration systems, it is recommended to maintain DO concentrations above 2 mg/l. The current nutrient and organic loading is in excess of the aeration system design and the likely cause of depressed oxygen concentrations.

4.2.3.4.2 Storage Lagoon

The coarse bubble diffusers in Lagoon #3 are supplied by the small blower in the pump house. The small blower run times were obtained from the City's SCADA system and are presented below in Chart 4-8.

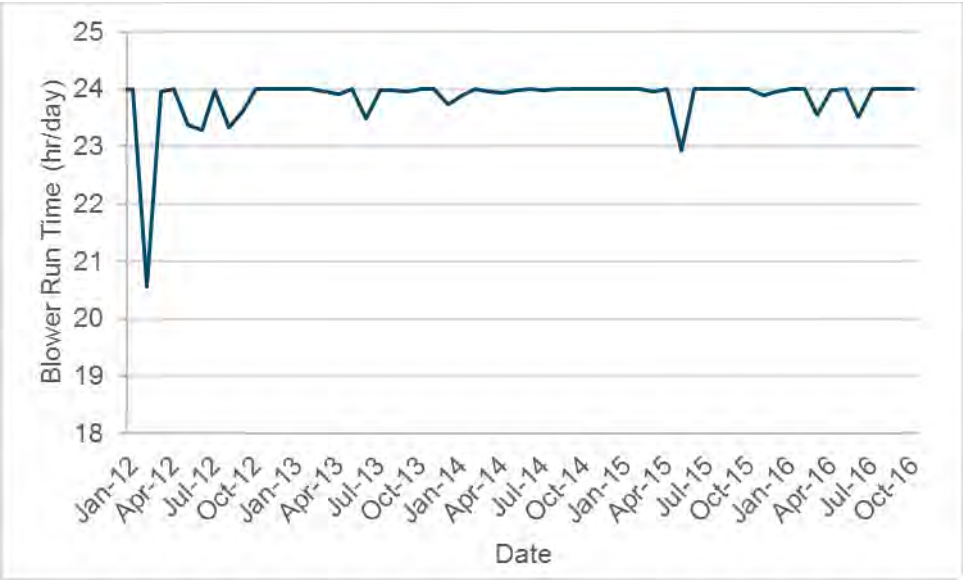


Chart 4-8: Average Small Blower Run Time

From January 2012 to October 2016, the small blower has essentially run constantly; average run times have remained at or near 24 hours/day. Conversations with the City suggest there have been no issues with icing around the lagoon's surface aerators. The June 2015 inspection by H&S Environmental noted that although the DO concentrations were low in Lagoon #1, concentrations greater than 12 mg/l were recorded in the storage cell and no odor related issues have been reported. This indicates more than sufficient oxygen is being supplied to the Lagoon #3.

4.2.3.5 Aeration DEQ-2 Standards

Circular DEQ-2 design criteria for partially mixed aerated lagoons includes a minimum dissolved oxygen level of 2 mg/l and provided mixing in the aerated cells of 5-10 HP/ MG. As previously discussed, a recent evaluation performed by H&S Environmental found DO concentrations as low as 0.01 mg/l in the primary treatment lagoon. Air is supplied to the treatment lagoons by three 100 HP motors; two of which have run continuously for the life of the current permit. The design operating capacity of each of the treatment cells is 16 MG, or 32 MG combined. According to *Wastewater Engineering, Treatment Disposal Reuse,* Third Edition by Metcalf and Eddy, typical efficiencies for blowers is 70% to 90%. These efficiencies estimated the mixing supplied to the treatment lagoons between 4.38 HP/MG and 5.63 HP/MG.

4.2.4 Pump Building

The existing pump building is a three-story, 3,000 SF concrete structure. The structure is located west of the lagoons, partially embedded in the dike. All electrical controls, pumps and blowers are in the pump building to simplify operations by providing a central control location.

The top floor of the building includes industrial work areas, air compressor, air intake filter and work benches. The blowers and associated motors, shown in Figure 4-3, along with electrical equipment are house on the mid-level. The bottom floor contains the five pumps and piping, shown in Figure 4-2. Conversations with City staff indicate the pump building is in good condition; during the October 2016 TD&H site inspection it was noted that the roof downspouts should be repaired or replaced.

4.3 Disposal

The City of Belgrade has two primary means of treated wastewater disposal, groundwater discharge through a series of IP beds and land application through spray irrigation. A minimal volume of treated water will evaporate from the ponds. Past design reports and Facilities Plans have estimated the yearly volume of evaporation at 5.5 MG or an average of 15,000 gpd. The remainder of the water is discharged through one of the two disposal methods detailed below.

4.3.1 Infiltration/Percolation (IP) Beds

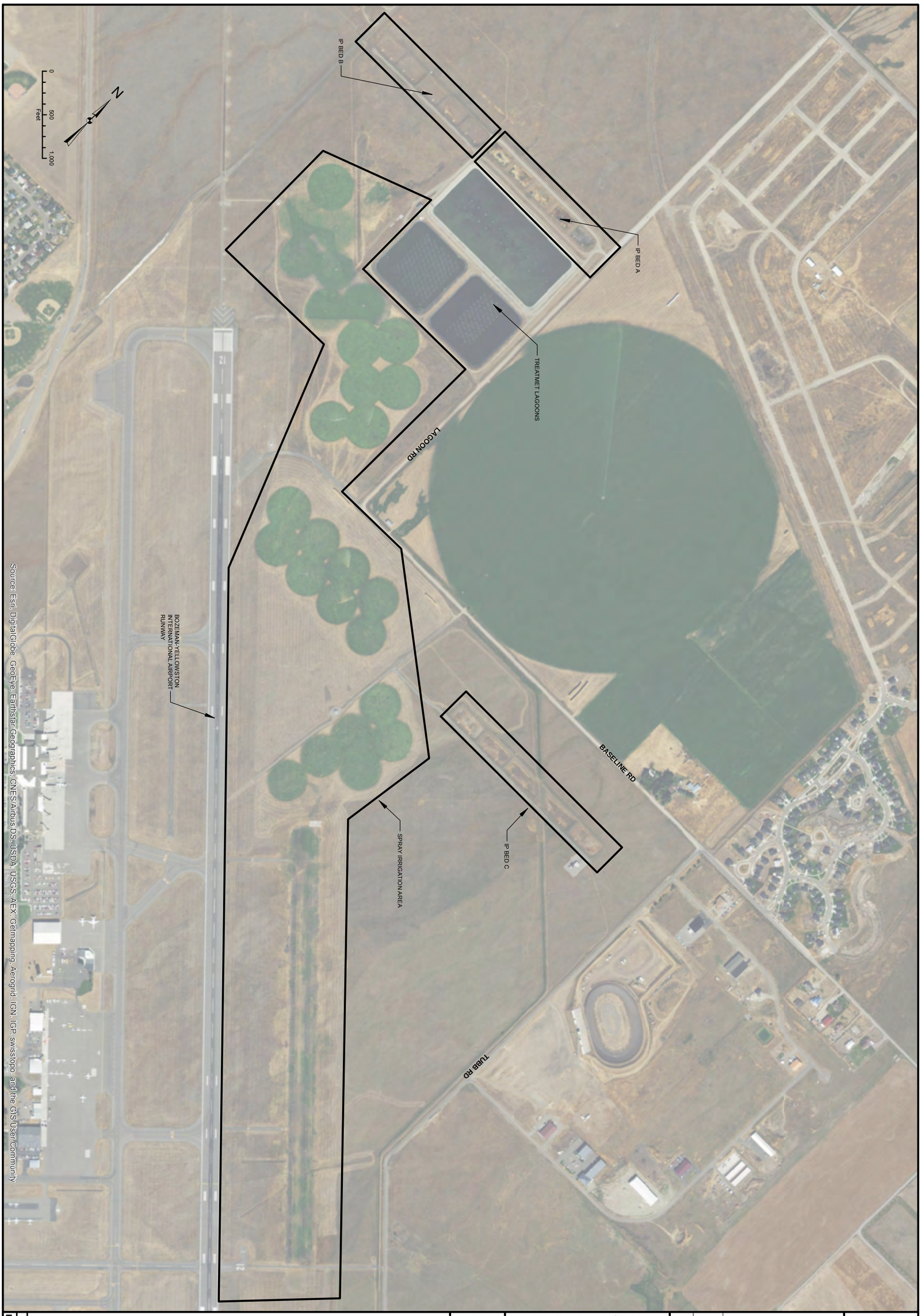
IP beds are a method of controlled, high rate land application to open, shallow, earthen basins that ultimately discharge to groundwater. The City's current groundwater discharge permit authorizes the BWTP to discharge treated residential strength domestic wastewater and sets limits on TN loading to each IP bed. The limits are set to maintain groundwater Nitrate concentrations below the human health standard of 10 mg/l. TN concentration are calculated as the sum of the concentrations of nitrates, nitrites, ammonia and TKN. Effluent from treatment lagoons similar to the BWTP generally have elevated concentrations of nitrates and nitrites due to the nitrification of ammonia that occurs in the lagoons. Denitrification converts the excess nitrates and nitrites to diatomic nitrogen (N_2). N_2 is a stable, mostly inert compound. It is only slightly soluble in water and will therefore leave the groundwater and evaporate into the surrounding air, which is comprised mostly of N_2. The denitrification process is facilitated by naturally occurring bacteria in the soil. Additionally, within the groundwater mixing zone, the natural groundwater flow will dilute and disperse the nitrogen compounds present in the treated effluent.

The three IP beds, known as Beds A, B and C, were constructed between 2000 and 2004. Bed A is the most recently constructed and was added to the BWTP in 2004 as part of the lagoon upgrade project. Bed B was the original IP bed and was installed in 2000. Both Beds A and B are in the SE ¼ of Section 36, Township 1 N, Range 4 E. Bed A is north of the lagoons, directly adjacent to Lagoon #3; Bed B is northwest of the lagoons, directly west of Bed A. Bed C was constructed in 2001, however effluent was not discharged to the bed until the transmission main was completed in 2004. Bed C is roughly 2,500 feet south east of the lagoons in NW ¼ of Section 6, Township 1 S, Range 5 E. A map of the IP bed locations is provided in Figure 4-5.

The treated wastewater is fed to each of the IP beds through two 12-inch force mains. IP Beds A and B are fed by the same transmission main; as such, the City is unable to discharge to Beds A and B simultaneously. The treated effluent is conveyed to the Beds by gravity or pressurized flow. Pump IP-1 has a 1,400 gpm capacity at 28 feet TDH. It is located in the lower level of the pump house and is utilized when gravity flow is not possible, generally in the winter months. When gravity flow is possible, the treated wastewater flows through a 10-inch PVC pipe, bypassing pump IP-1 and discharging to the 12-inch transmission main upstream of the magnetic flow meter, M-1. Figure 4-2 displays the pump and piping configuration for the BWTP.

A second 12-inch transmission main is used to discharge effluent to IP Bed C. Due to the topography of the area, gravity flow is not possible. Pump IP-2 is needed to convey treated wastewater through the transmission main to Bed C. IP-2 has a 1,400 gpm capacity at 67 feet TDH and is house in the lower level of the pump house; it can be seen in Figure 4-2. This transmission main is used to transport effluent to both IP Bed C and the irrigation system, and as such the City cannot discharge to both simultaneously. A separate pump is used for the irrigation system, however. A magnetic flow meter, M-2, has been installed on the transmission main to measure flow.

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\B16-048 Fig 4-5.mxd



BELGRADE WASTEWATER MASTER PLAN

BELGRADE, MONTANA

DISPOSAL SYSTEM LOCATIONS

FIGURE 4-5

B16-048 Fig 4-5.MXD

DRAWN BY: CJS
DESIGNED BY:
QUALITY CHECK:
DATE DRAWN: 04/11/2017
JOB NO.: B16-048
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Each of the three IP beds are constructed in the same manner. Five cells are arranged linearly from east to west. Each cell is approximately 100 feet by 200 feet, providing nearly 20,000 SF of infiltration area in each cell, or 100,000 SF in each bed. The cells are 5 feet deep with 4:1 side slopes. Approximately 1,100 LF of 12-inch PVC runs east-west along the southern dike of each bed. Ten 8-inch laterals branch off the 12-inch main, two into each of the 5 cells. Each lateral has an 8-inch remote operated gate valve to direct effluent into the cells. A concrete pad is included at the outfall of each lateral to help prevent erosion. A 10-inch emergency overflow DI pipe connects each cell to the adjacent cell. A summary of the IP Bed components is available in Table 4-15 and a schematic of the is presented in Figure 4-6.

Table 4-15
Infiltration/Percolation Components

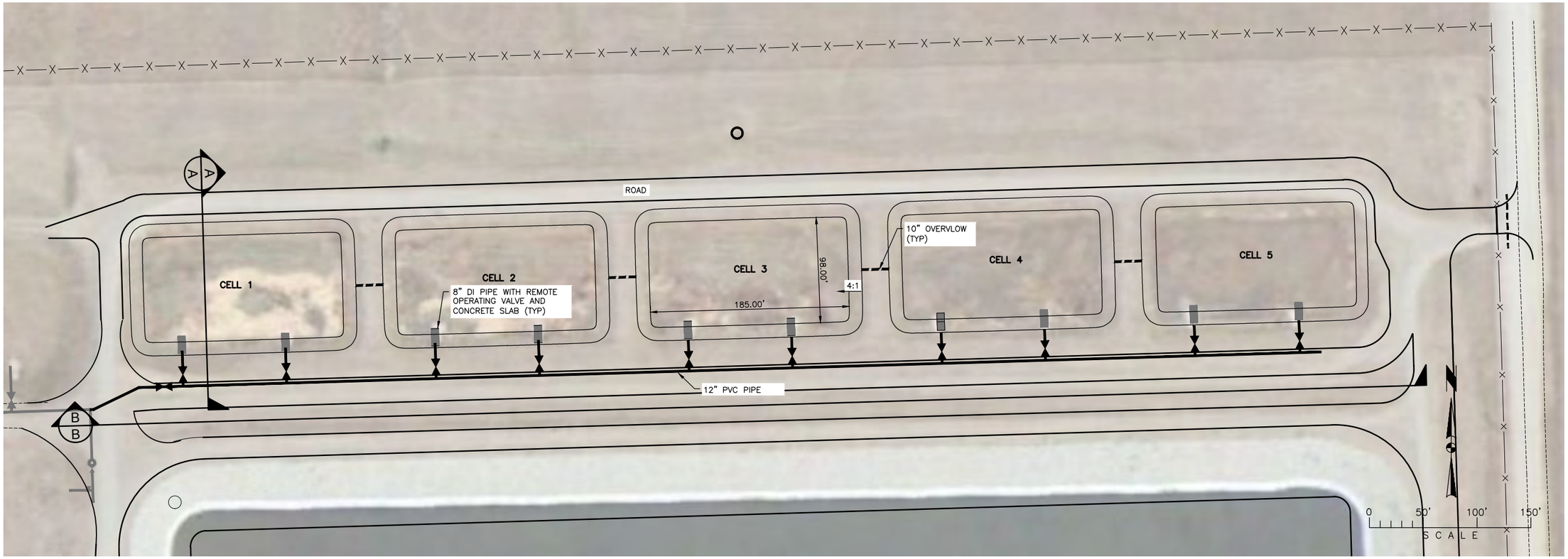
Number of Beds	3
Cells per Bed	5
Cell Length	100 feet
Cell Width	200 feet
Cell Depth	5 feet
Pump IP-1	1,400 gpm at 28 feet TDH
Pump IP-2	1,400 gpm at 67 feet TDH
Header Pipe	1,100 LF of 12-inch PVC
Lateral Pipe	8-inch PVC
Number of Laterals (per bed)	10

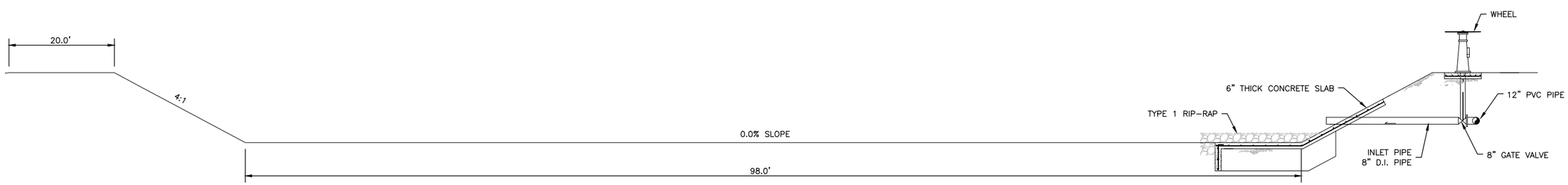
A system of monitoring wells has been installed to measure groundwater quality downstream of each IP Bed. One monitoring well is upstream of Beds A and B and a second upstream of Bed C. These wells are used to determine background levels of contaminants in the groundwater. Monitoring well locations can be seen on Figure 4-7.

4.3.1.1 IP Bed Conditions

Conversations with City personnel suggest the overall condition of the IP Beds is good. No issues with dike erosion or header or lateral pipe failures have been reported. However, concerns involving existing vegetation were expressed. According to the plant operator, Mr. Paul Burkardt, the existing vegetation consists mainly of native weeds; a more site specific plant to facilitate denitrification would be preferable.

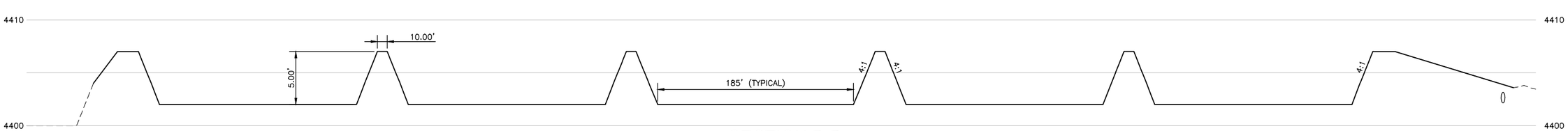
In a recent site visit by TD&H Engineering it was noted that the City would prefer more automated controls for directing flow between IP Beds A and B rather than the current manual operations. Additionally, programming issues with the remote-controlled values directing flow into the separate IP cells were described in more recent conversations with City staff.





SECTION A-A

NO SCALE



SECTION B-B

NO SCALE

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TD&H Engineering
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DRAWN BY:	CJS
DESIGNED BY:	
QUALITY CHECK:	
DATE:	04/05/2017
JOB NO.	B16-048
FIELDBOOK	

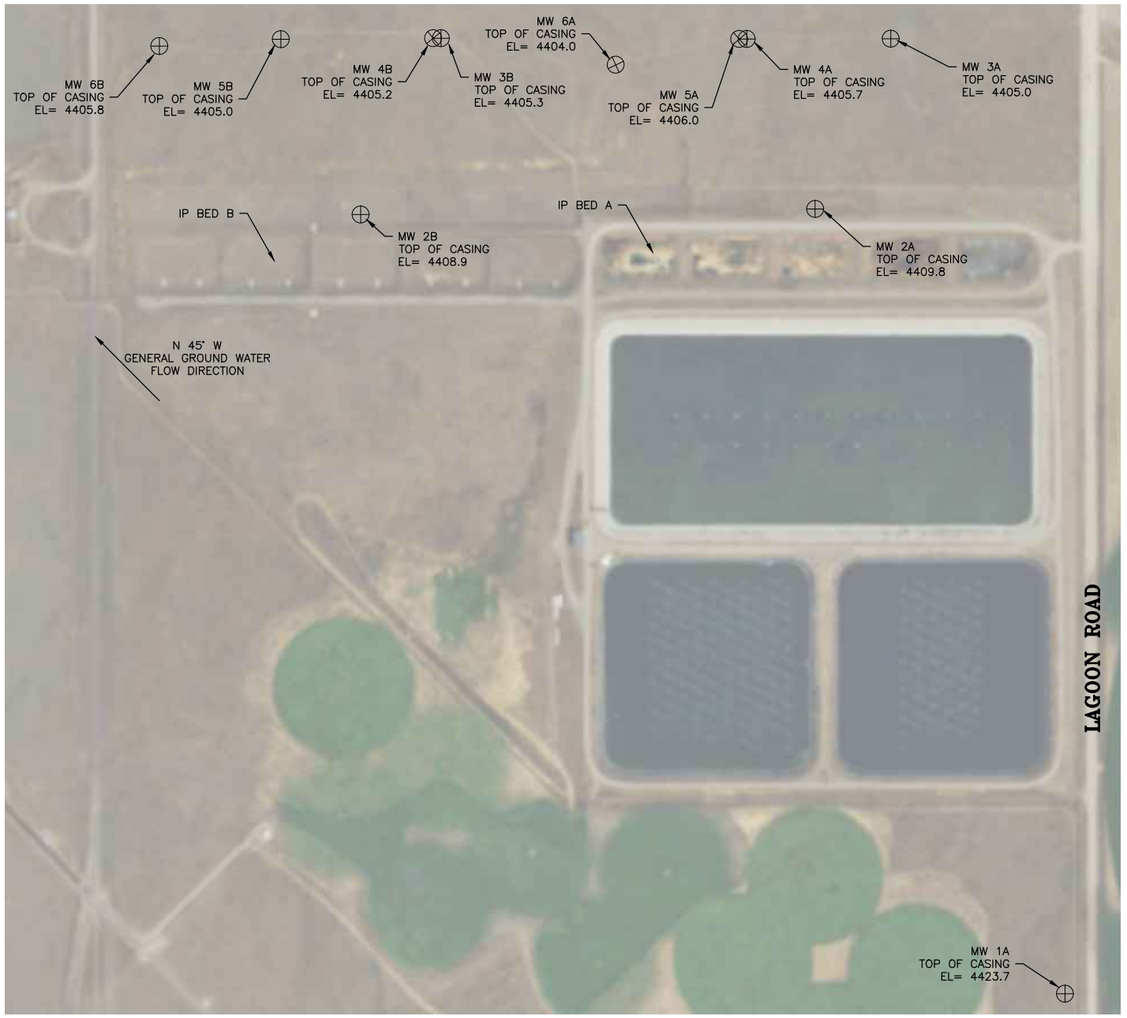
BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MT

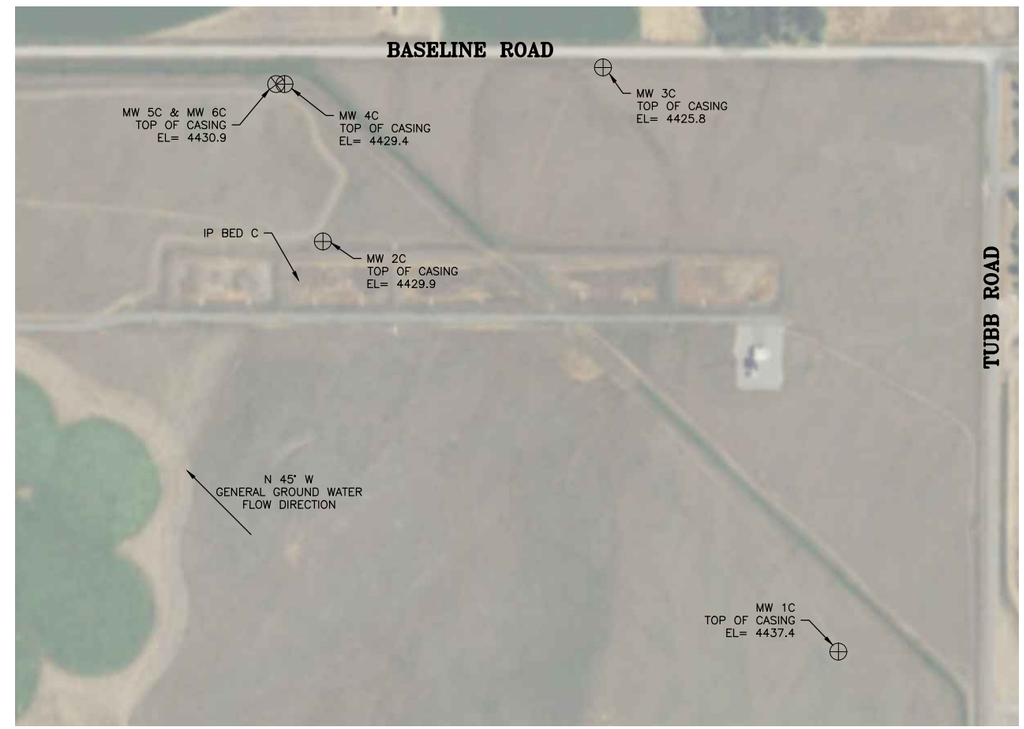
TYPICAL IP BED SCHEMATIC

FIG 4-6.DWG

FIGURE 4-6

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 4-6.dwg, 4/28/2017 2:34:08 PM, cjs





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0 200' 400' 600'
S C A L E

NOTES:

1. ELEVATIONS SHOWN ARE NAVD88 BASED ON THE MTSU CORDS STATION

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QUALITY CHECK:	
DATE:	04/12/2017
JOB NO.	B16-048
FIELDBOOK	

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

MONITOR WELL LOCATIONS

FIG 4-7.DWG

FIGURE 4-7

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 4-7.dwg, 4/28/2017 2:39:52 PM, cjs

4.3.1.2 IP Bed Capacity

4.3.1.2.1 Hydraulic Capacity

As previously mentioned, each of the IP Beds is fed by a 12-inch transmission main. IP Beds A and B may be fed by either gravity or pressurized flow, while treated wastewater can only be conveyed to IP Bed C through pressurized flow. The magnetic flow meter M-1 measures flow to IP Beds A and B and records flow rates to the City's SCADA system. Flow data from M-1 was downloaded and evaluated to calculate the monthly average day flows from December 2012 to October 2016. It was determined that average monthly flows to IP Beds A and B peaked in winter months. Average flows ranged from 0 gpd in July 2014 to 303,411 gpd in September 2016 and averaged roughly 142,000 gpd.

Pump IP-1 is used to convey treated wastewater to Beds A and B. Run times were downloaded from City's SCADA system. Pump run times are recorded daily in hours per day (hr/day). Pump runs indicate pressurized flow occurs mainly in the winter months. The minimum monthly run time for each month from December 2012 to October 2016 was 0 hr/day, indicating the pump does not run every day, even during peak discharge months. The maximum monthly run time peaked in February 2016 with 14 hours per day. Average monthly run times for months with pressurized flow ranged from 0.0027 hr/day to 3.845 hr/day and averaged 1.86 hr/day. Calculations are available in Appendix 4.

Pump IP-1's nominal capacity of 1,400 gpm was used to calculate flow rates based on monthly average run times. This information is presented in conjunction with measured monthly average day flow rates to IP Beds A and B, as calculated from the available SCADA data in Chart 4-9. Detailed calculations are available in Appendix 4.

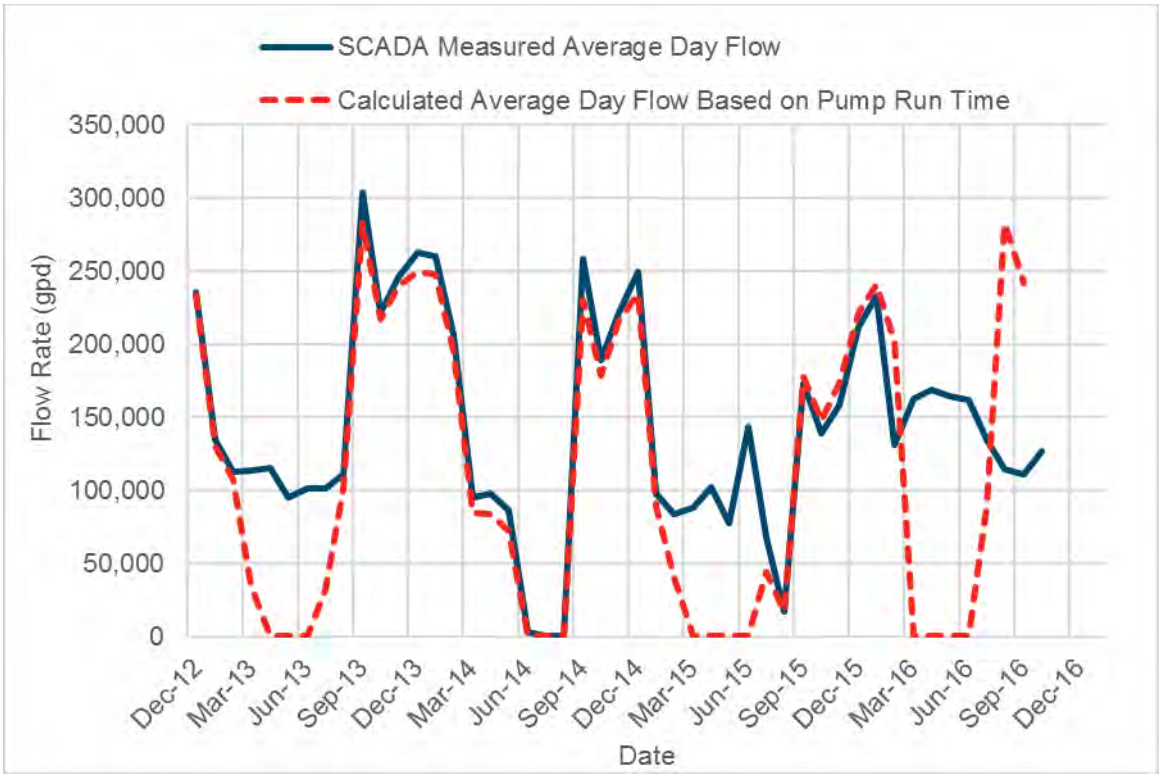


Chart 4-9: Average Flow Rates to IP Beds A and B Combined

Average flow rates based on pump run times match closely with measured flow rate from the SCADA system in the winter months. This suggests pump IP-1 is operating as designed. During the summer months, average flows calculated from pump run times are consistently 0 gpd; average flow rates measured from M-1 show active flow, indicating only gravity flow occurs in the summer.

Further analysis of the effluent discharge was completed using the data reported to the DEQ through the required DMR. DMR data indicates the City has not discharge to IP Bed B for the duration of the current permit, December 2012 to the present. According to City Staff, discharge of treated wastewater to IP Bed B led to number of permit violations during the previous permit cycle. As such, the City has decided to discharge to Beds A and C as much as possible, and use Bed B only if necessary. The average day flow rates reported for IP Bed A closely match the data collected from the SCADA. It is unclear at this time what caused the elevated groundwater nitrate concentrations in IP Bed B's mixing zone. One possible explanation is leakage from the treatment lagoons. However, as discussed previously, more accurate is needed before leakage can be confirmed. At a minimum, 30 consecutive days of accurate flow measurements from a new, reliable influent flow meter will be required to complete a system water balance and confirm if the pond liners are damaged and leaking. As the population and flow rate continue to increase, the City will need to utilize the available disposal capacity of IP B.

A second transmission main conveys treated wastewater to IP Bed C and the irrigation system. Pump IP-2 is used to transport the effluent to Bed C, while the irrigation pump, discussed in detail later, pumps water to the irrigation system. A single magnetic flow meter, M-2, measures flow through the shared transmission

main. M-2 records effluent flow rates to the City's SCADA system but does not distinguish which pump is running. To comply with the City's discharge permit, operators manually record specific IP Bed flow data to the DMR.

Daily run times for pump IP-2 were downloaded from the City's SCADA system. Minimum monthly run times were consistently 0.0 gpd for all months from December 2012 to October 2016, indicating IP-2 has not run every day for any one month during the current permit. The maximum monthly flow rate peaked at 24 hr/day in March and February of 2014. It is unclear at this time what caused the pump to run continuously for 24 hours, however this is believed to be an anomaly and not representative of the system. The average monthly run times for IP-2 for the winter months ranged from 0.55 hr/day in April 2014 to 3.99 hr/day in February 2014 and averaged 1.41 hr/day.

The nominal capacity of IP-2 is 1,400 gpm. Flow rates were calculated based on monthly average run times and compared to measure SCADA flow rates for winter months. DMR data shows IP Bed C does not receive treated wastewater during summer months. The average flow rate reported to the DMR was also compared to the recorded SCADA average flows. A few discrepancies were found where the reported DMR flows were noticeably higher then measured SCADA flow rates. A recent test of the City's flow meters confirmed M-2 was performing as expected and measured flows could be considered accurate. For that reason, flow measurements taken directly from the SCADA system were referenced to evaluate the hydraulic capacity of pump IP-2. Detailed calculations are provided in Appendix 4. The comparison is presented in Chart 4-10.

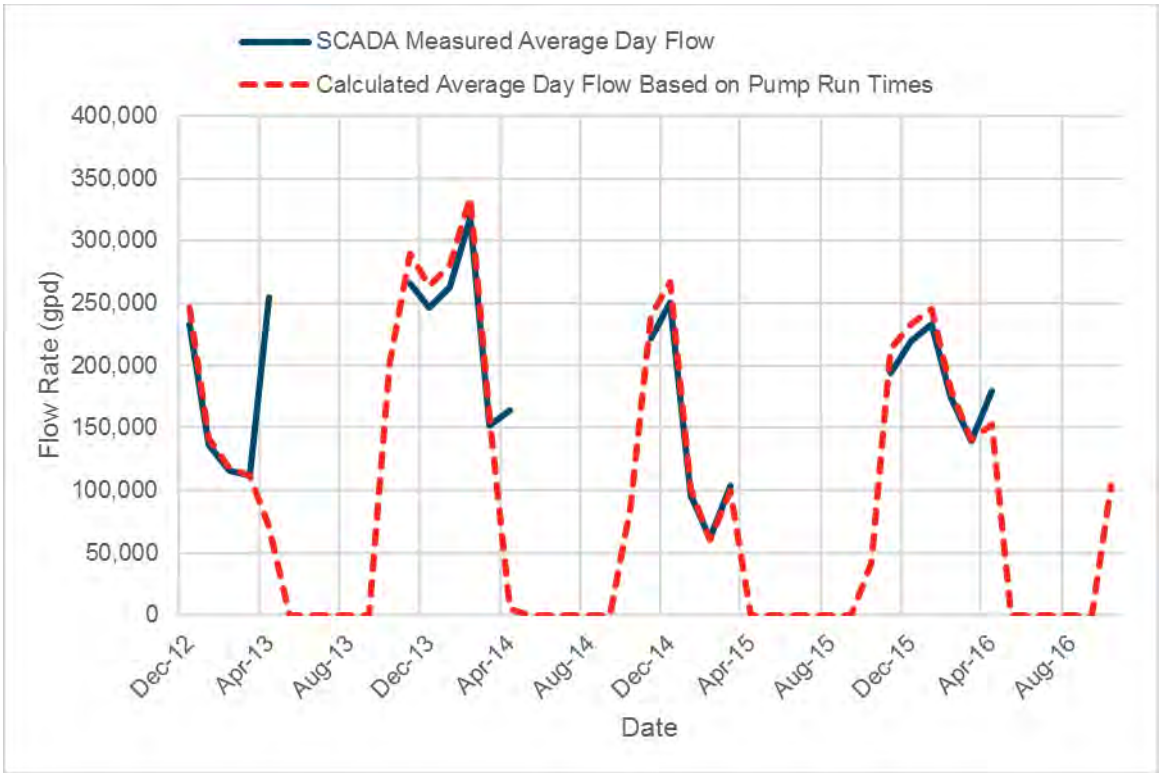


Chart 4-10: Average Flow Rates to IP Bed C

The analysis presented in Chart 4-9 shows the actual flow recorded by the City's SCADA system closely matches the average flow rate calculated using average pump run times for the winter months This indicates IP-2 is operating as designed and has not consequentially decreased in efficiency with time. This analysis also verified the assumption that treated wastewater is not discharged to IP Bed C during summer months as flow based on recorded pump run time equal 0.0 gpd through the warmer months.

4.3.1.2.2 Nutrient and Organic Capacity

As mentioned in Chapter 2, the City of Belgrade is allowed to discharge 72 ppd of TN to IP Beds A and B and 74 ppd of TN to IP Bed C per their groundwater discharge permit. The City's DMR were downloaded from the DEQ website and referenced to evaluate the capacity of the existing IP Beds.

As mentioned previously, the City has not discharged to IP Bed B since November 2012. Average day TN loading for IP Beds A and C from December 2012 to October 2016 is presented in Chart 4-11 and 4-12.

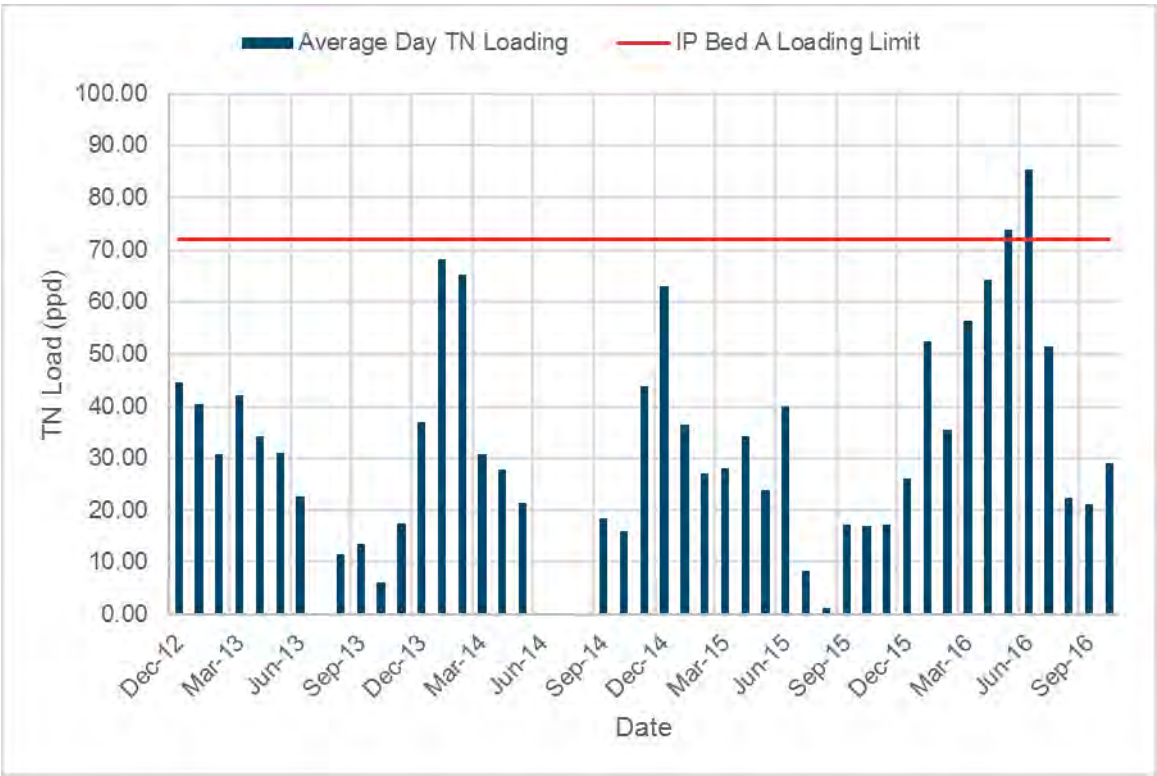


Chart 4-11: IP Bed A Historic Total Nitrogen Loading

The BWTP has increased the TN loading to IP Bed A over the life of the current permit. Average day TN loading to Bed A has remained consistently below the permit level of 72 ppd except for a brief exceedance of the allowable limit in May and June of 2016 with 73.89 and 85.50 ppd, respectively. This exceedance has been attributed to spring turnover. In the short term, the exceedances may be avoidable if the IP Bed B could be used to for disposal for a portion of the volume discharged when concentration spikes occur.

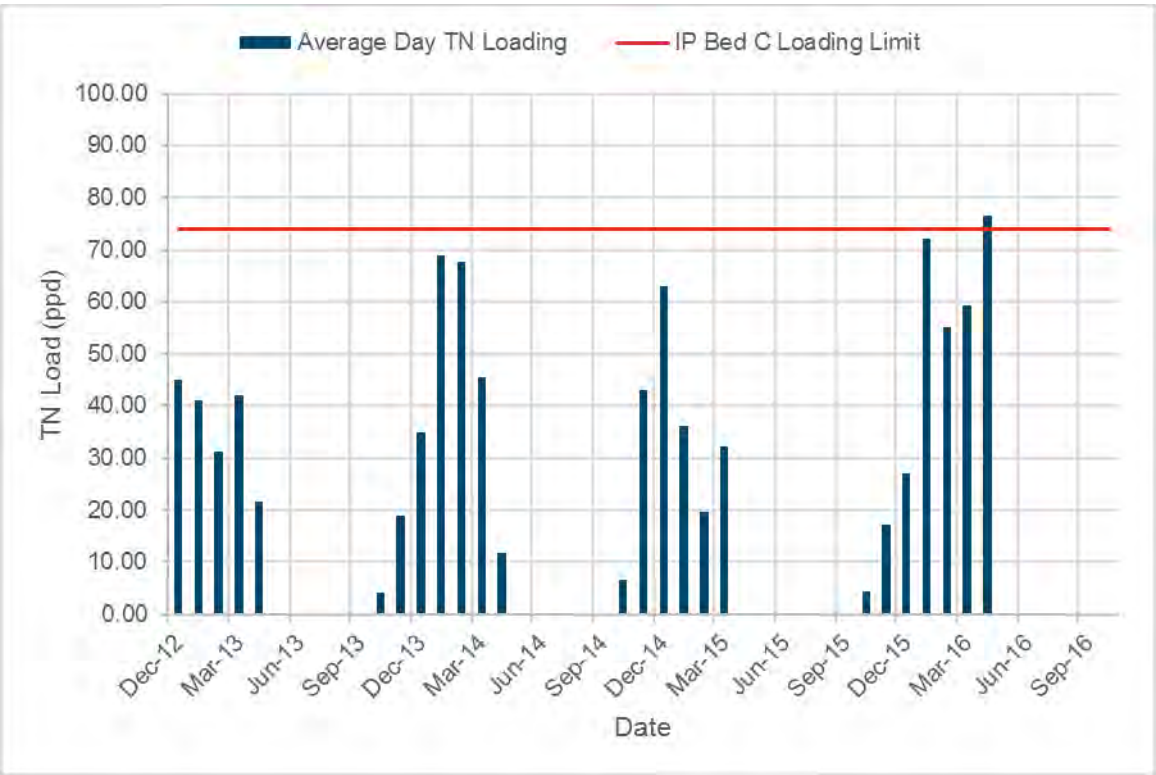


Chart 4-12: IP Bed C Historic Total Nitrogen Loading

The TN loading to IP Bed C has steadily increased over the life of the permit. A slight exceedance of the 74 ppd loading limit was witnessed in April of 2016 with an average recorded TN loading of 76.42 ppd.

Based on the above information, IP Beds A and C are at or near their nutrient capacity. As the effluent flow rate increases with time, the BWTP will need to consider discharging to IP Bed B, discharging to A more frequently or altering the system to allow treated wastewater to be discharged to all disposal methods simultaneously.

4.3.1.2.3 Monitoring Wells

As mentioned previously, the City has a system of monitoring wells to measure groundwater concentrations. Monthly samples are tested each month for groundwater concentrations of chloride, Nitrate + Nitrite (as N), TKN (as N) and TN. Figure 4-7 shows the locations of all monitoring wells. For the duration of the current permit, sampling is not required for six of the existing wells. Samples have been taken from wells 1A, 3A, 5A, 6A, 4B, 5B, 6B, 1C, 3C, 5C and 6C. The letters in each of the monitoring well names corresponds to the specific IP Bed's mixing zone the well is monitoring. Wells 1A and 1C are installed upstream of the IP beds and are tested for background concentrations. Per the City's discharge permit, groundwater TN concentrations must remain below the human health standard of 10 mg/l TN. As shown in Chart 4-13, TN concentrations of the downstream monitoring wells are generally below 5 mg/l. A minimal number of samples have reported values between 5 and 10 mg/l TN and one sample take from well 6B in September of 2016 reported a TN concentration of 27.6 mg/l. It is

unclear at this time what caused the spike, however no other well reported high values. Additionally, the City has not discharged to Bed B since the current permit became effective in 2012. For these reasons, it is believed that this value is an anomaly and not representative of the system. Raw groundwater quality data is included in Appendix 4.

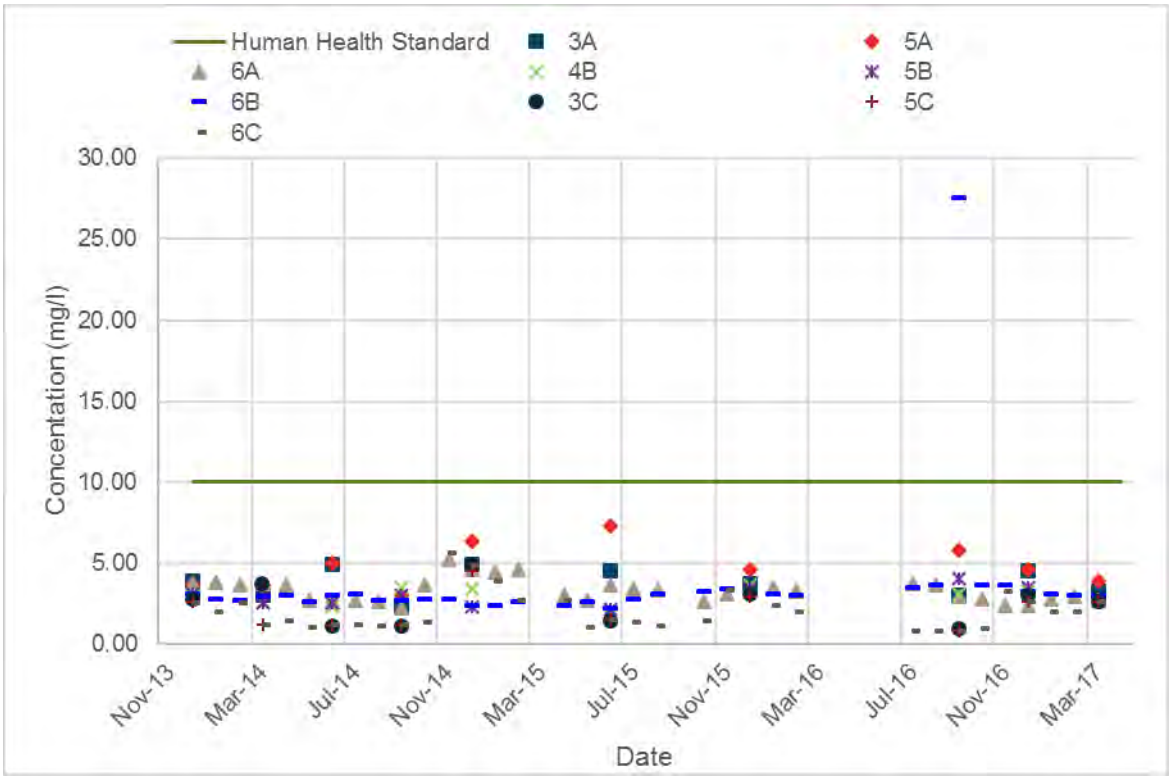


Chart 4-13: Total Nitrogen Groundwater Concentrations

4.3.1.3 DEQ-2 Design Standards for Infiltration/ Percolation Systems

Section 122 of Circular DEQ 2 Details the design standards for new IP beds. According to the Circular, IP beds must not be located within the 100-year flood plain or within 500-feet of a water supply well. All IP cells must have an inlet structure designed to mitigate erosion within the cells and flow should be distributed evenly among the entire IP system. Side slopes are not to be steeper than 3:1 and an access road is to be provided for maintenance. Intercellular overflow piping is to be included; however, overflow piping that discharges outside of the basin area is not permitted.

The BWTP has not discharged to IP Bed B for the duration of the current permit, and therefore does not evenly distribute the treated wastewater flow through the IP system. All other aspects of the IP system are in compliance with DEQ-2 standards.

4.3.2 Irrigation

The City's spray irrigation system is considered a non-discharging outfall. It is therefore exempt from the TN loading requirement, provided the treated effluent is irrigated at agronomic rates and does not introduce additional nitrogen to the groundwater.

The BWTP irrigation system was designed by Morrison Maierle, Inc in 2002 and is owned by the

Bozeman-Yellowstone International Airport. The system is located south and west of the treatment lagoons, extending in a strip parallel to the Airport's runway. It covers approximately 117 acres. Figure 4-5 shows the location of the irrigation system in relation to the rest of the BWTP. Table 4-16 summarizes the irrigation components.

Table 4-16
Irrigation Components

Pump	1,200 gpm at 237' TDH
Irrigated Area	117 acres
Transmission Main	5,400 feet of 12-inch PVC 4,800 LF of 10-inch PVC
Number of Laterals	26
Number of Sprinkler Heads	52
Individual Sprinkler Coverage Radius	200 feet

The 12-inch transmission main used to transport treated wastewater to Bed C is also used for the irrigation system. As such, the City is not able to discharge to Bed C and the irrigation system simultaneously. Treated wastewater is discharged to the transmission main from the irrigation pump. The irrigation pump is located in the pump house with a capacity of 1,200 gpm at 237 feet TDH. The 12-inch main extends approximately 5,400 LF to IP Bed C, the main then reduces to a 10-inch PVC and travels roughly 4,800 LF parallel to the airport runway. Pressure relief valves are installed near the upper end of the line to protect the system from high pressures. Additionally, several combination air relief and vacuum valves are included at the high points along the main.

Twenty-six laterals branch off the transmission main. There are two fixed sprinkler heads on each lateral, each with a coverage radius of 200 feet. The irrigation system is automatically controlled by the irrigation controller.

The irrigation system is designed to only be used as a disposal method in the summer months, for 127 days from May to September. Under normal operating conditions, only two laterals are open at a time, with a total flow of 1,200 gpm. Occasionally, three laterals may be opened for a total flow of 1,800 gpm.

4.3.2.1 Irrigation Conditions

During the October 2016 site inspection, it was noted that the existing irrigation system requires extensive maintenance. Further discussions with City staff indicated continual maintenance is required for the sprinkler heads. Additionally, the plant operator, Mr. Paul Burkardt, described the irrigation chart recorder as difficult to read. Mr. Burkardt also expressed concerns regarding time conflicts with local farmers. The irrigation system is not able to run for two to three weeks in both the spring and fall to allow the hay to be bailed. The City has indicated its desire for additional irrigation area to mitigate the inconvenience of these conflicts.

No issues specific to the piping of the irrigation system were noted. The pump seal on the irrigation pump is to be replaced by City staff; no other O&M issues with the irrigation pump were identified.

4.3.2.2. Irrigation Capacity

As discussed previously, treated wastewater is conveyed to the irrigation system through a 12-inch force main shared with IP Bed C. A magnetic flow meter, M-2, measures flow through the transmission main.

Run times for the irrigation pump, shown in Figure 4-2, were downloaded from the City's SCADA system for December 2012 to October 2016. Based on this information, the BWTP has not discharged to the irrigation system during the winter months for the duration of the current permit. During the irrigation season, monthly average run times range from 0.085 to 21.46 hr/day and averaged 9.94 hr/day.

The irrigation pump was designed with a nominal capacity of 1,200 gpm. Monthly average day flow rates to the irrigation system were calculated by multiplying the nominal capacity by the average pump run time. These calculated flow rates were compared to flow rates recorded to the SCADA system by M-2. Flow rates recorded during the winter months were not included because the analysis performed in Section 4.3.1.2.1 confirms flow measured by M-2 during the colder months was discharged to IP Bed C. Detailed calculations are provided in Appendix 4. The comparison is presented in Chart 4-14.

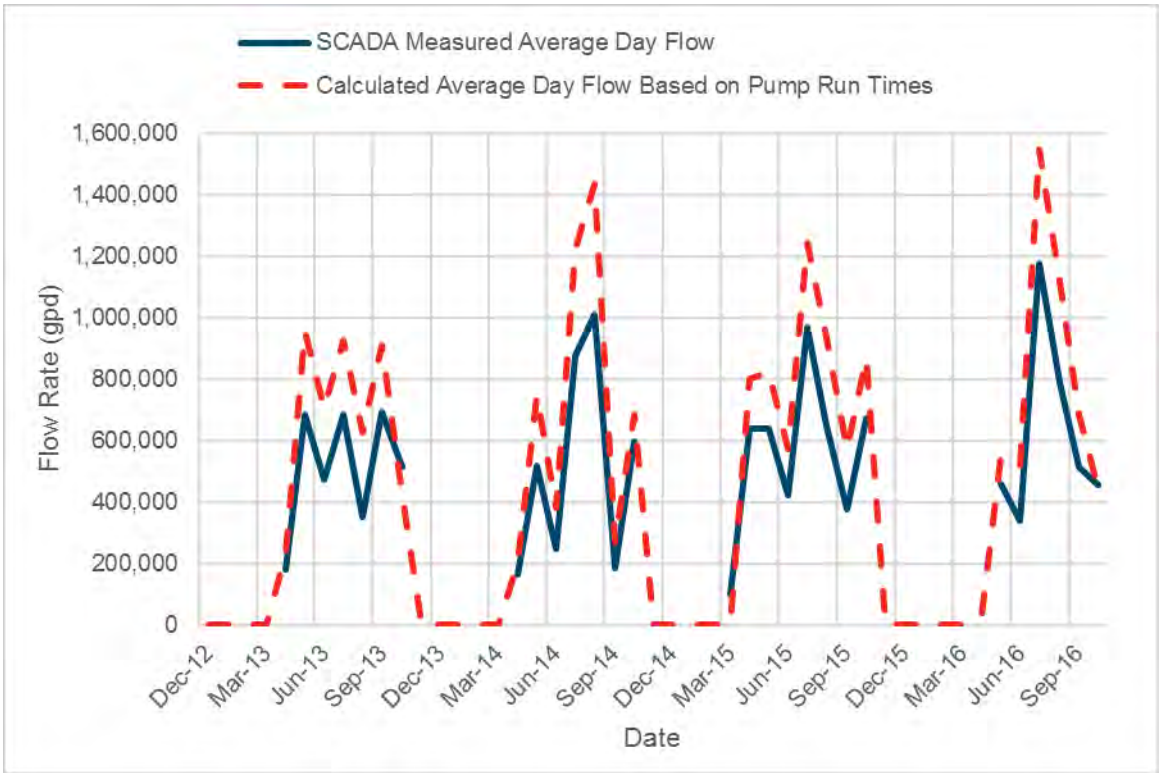


Chart 4-14: Irrigation Average Day Flow Rates Comparison

The predicted average day flow rates, based on pump run times, have been consistently higher than the measured flow from the SCADA system. This indicates the irrigation pump may not be operating as efficiently as designed. Because of the high average run times during the irrigation season, it is likely that the pump has begun to wear and the efficiency has decreased. This may also be caused unanticipated head loss within the

irrigation system. It is also possible that the buildup and mineralization within the transmission piping has occurred with time, increasing the TDH. Through the duration of the current permit, the flow rate calculated based on pump information has ranged from approximately 10% to 45% higher than the measured flow, averaging 26% higher.

Because this irrigation system is classified as a non-discharging disposal method, it is not included as an outfall on the City's discharge permit. Therefore, the City is not required to report irrigation flow to the DMRs. For this reason, the recorded SCADA data could not be compared to the reported DMR average day flow.

In order to maintain the irrigation system's status and a non-discharging outfall, the BWTP must not exceed the irrigation agronomic rates. The system was designed to discharge 744,000 gpd over 117 acres for a 127-day irrigation season, from May 16 to September 20. The design calculations assumed 28.0 mg/l TN in the treated wastewater. Based on these parameters, Morrison Maierle, Inc. calculated allowable monthly application rates for the 2002 *Effluent Spray Irrigation System Gallatin Field Airport Design Report*. This report was included as part of the 2004 Belgrade Wastewater Treatment Plant Operations and Maintenance Manual. The application rates are presented below in Table 4-17.

Table 4-17
Agronomic Rates

Month	Operating Day	Application Rate	
		(inches)	(gpd)
January	0	0	0
February	0	0	0
March	0	0	0
April	0	0	0
May	16	3.5	694,980
June	30	7	741,312
July	31	10.1	1,035,104
August	31	9.4	963,364
September	20	4.8	762,492
October	0	0	0
November	0	0	0
December	0	0	0

Irrigation flows recorded in the City's SCADA system were compared to these agronomic rates. SCADA data for the summer months was utilized because no irrigation DMR records exist. Irrigation flow rates have increased over the life of the current permit. During the summer of 2013, the City discharged at an average of 71% of the agronomic rates. The summer of 2016 saw a discharge rate that averaged 75% of the design agronomic rates.

The irrigation system's agronomic rates were calculated assuming 28 mg/l TN in the effluent. Monthly samples are collected at the effluent tap in the pump house and analyzed by Energy Laboratories, Inc. Effluent TN concentrations are highest in the first part of summer and have consistently exceeded the design concentration of 28 mg/l. TN

concentrations ranging from roughly 30 to 40 mg/l in April, May and June from 2014 to 2016. In the later summer months, July, August and September, TN concentrations significantly decreased and remained below the design concentrations. Appendix 4 includes Charts showing the effluent TN concentration trend.

The actual agronomic rates for the City of Belgrade were calculated using historic total nitrogen concentration data along with the soil and nutrient data used in the 2002 irrigation system design calculations. The actual agronomic rates in the late summer months are larger than originally predicted. Chart 4-15 compares actual agronomic rates to actual flow data, calculations provided in Appendix 4.

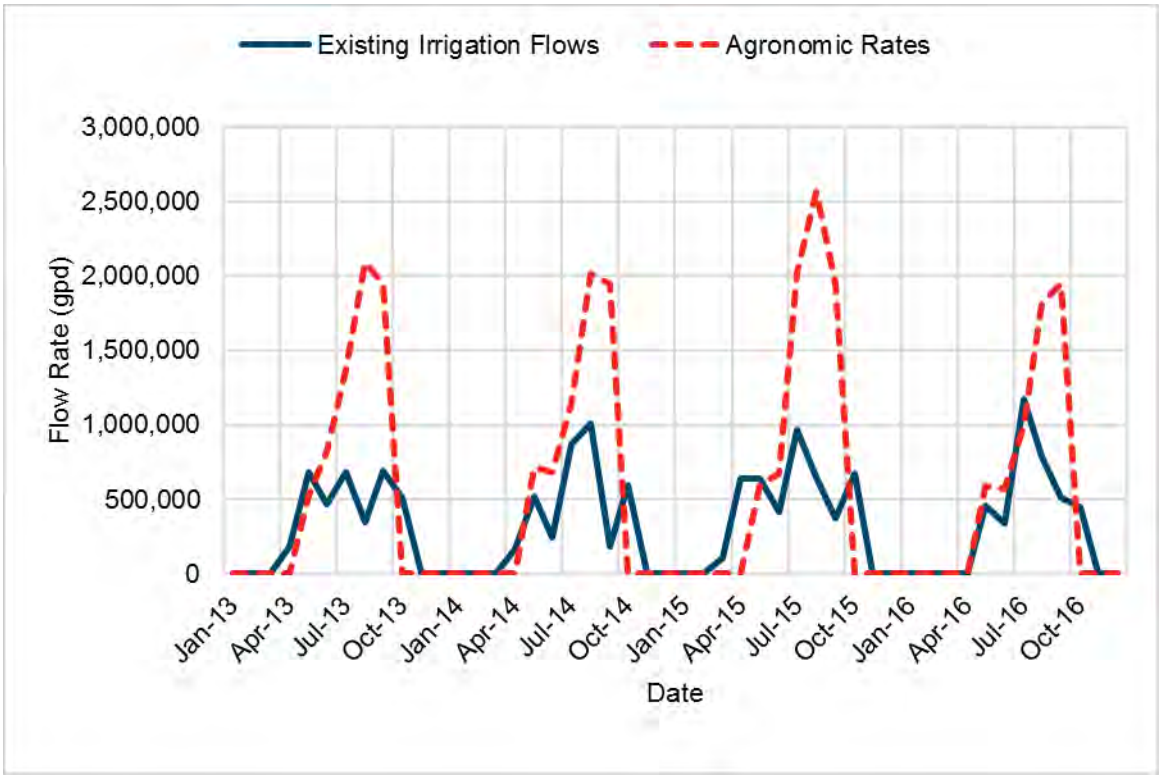


Chart 4-15: Existing Irrigation Rates vs Calculated Agronomic Rates

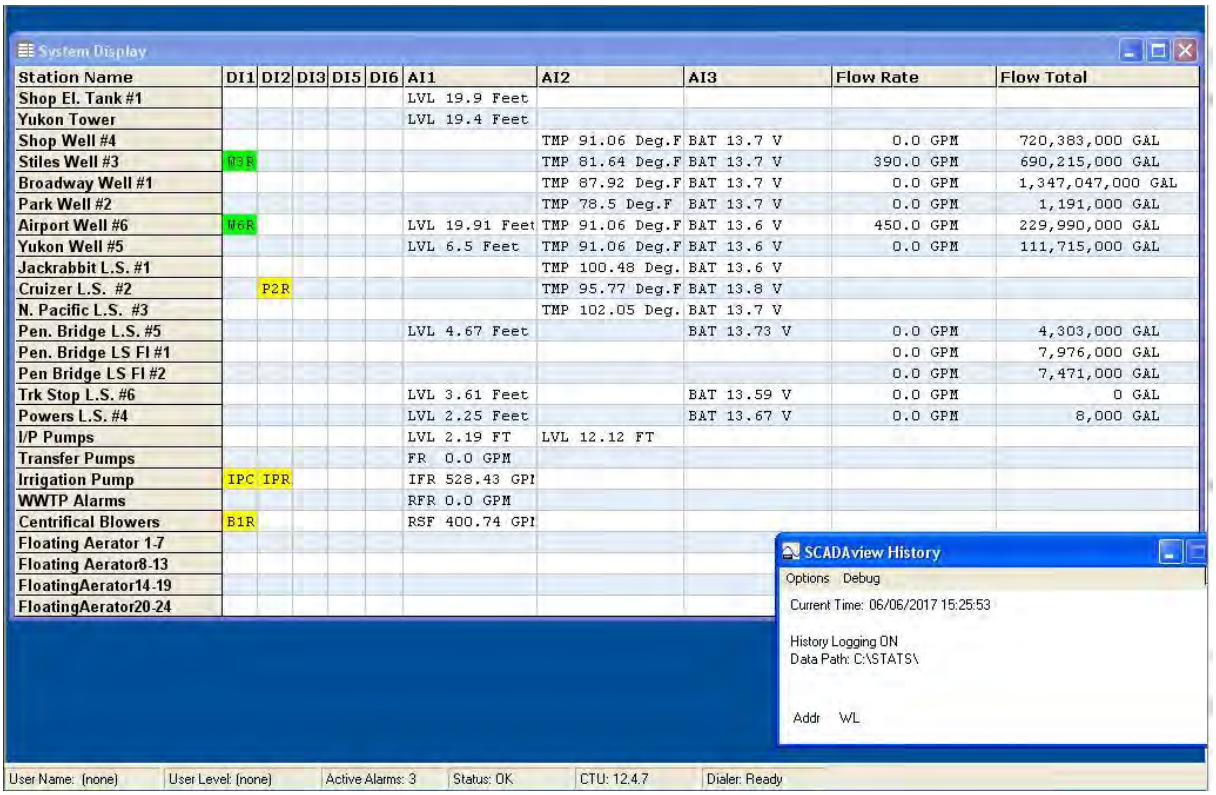
As Chart 4-14 shows, the historic irrigation flows have been below actual agronomic rates for most of the irrigation seasons from 2013 to 2016. The City has extended the irrigation season past the design conditions for the past four year. The irrigation flows during this time are not considered to be large enough to effect groundwater quality, however. Additionally, because the magnetic flow meter measuring flow to the irrigation system also records flow to IP Bed C, it is possible that a portion of the flow reported during the spring and fall months may have been discharged to IP Bed C. This analysis indicates that the current irrigation system has sufficient capacity to serve the existing system.

4.4 Belgrade SCADA Planning

As part of the infrastructure improvements previously discussed, the City will need to upgrade the current control system to have the ability to efficiently monitor and control new and existing infrastructure and equipment. Currently, the control system is Microcomm-based equipment and provides minimal monitoring, reporting, or automated control of the existing facilities.

4.4.1 Monitoring and Reporting

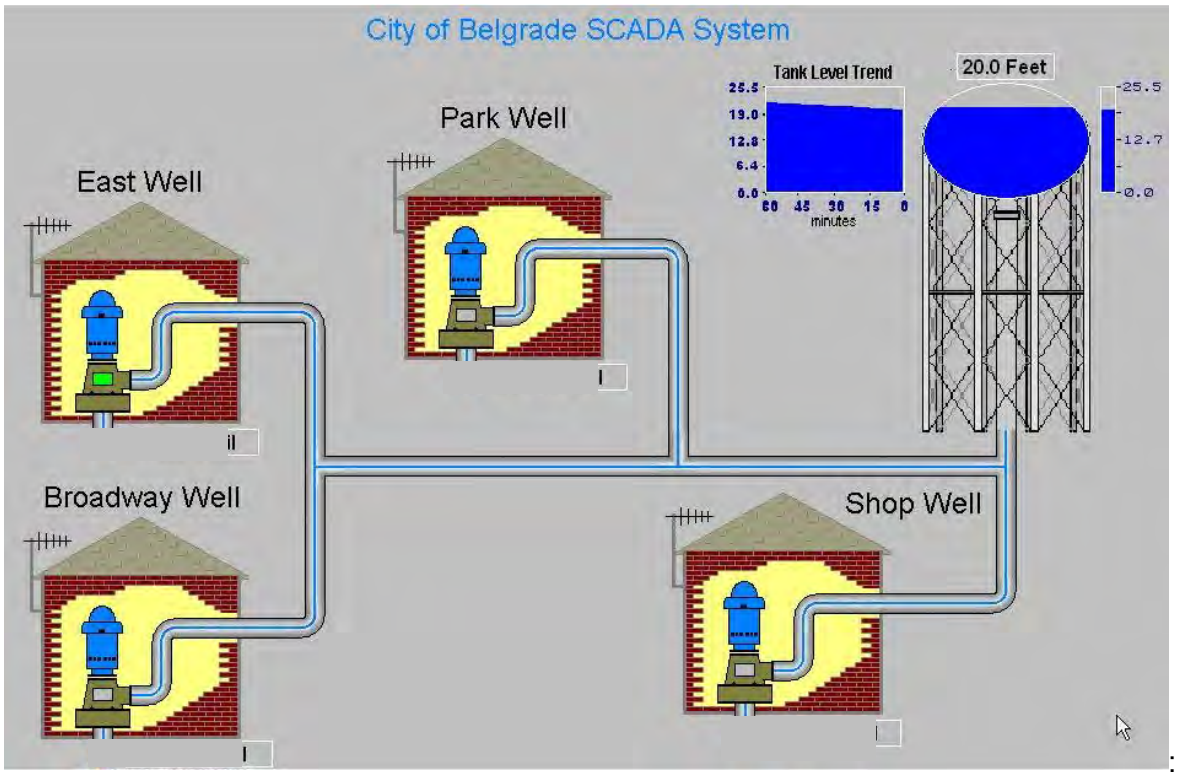
The existing SCADA system provides system monitoring and reporting for the facilities listed in the screen capture, below.



Station Name	DI1	DI2	DI3	DI5	DI6	AI1	AI2	AI3	Flow Rate	Flow Total
Shop El. Tank #1						LVL 19.9 Feet				
Yukon Tower						LVL 19.4 Feet				
Shop Well #4							TMP 91.06 Deg.F	BAT 13.7 V	0.0 GPM	720,383,000 GAL
Stiles Well #3	W3R						TMP 81.64 Deg.F	BAT 13.7 V	390.0 GPM	690,215,000 GAL
Broadway Well #1							TMP 87.92 Deg.F	BAT 13.7 V	0.0 GPM	1,347,047,000 GAL
Park Well #2							TMP 78.5 Deg.F	BAT 13.7 V	0.0 GPM	1,191,000 GAL
Airport Well #6	W6R					LVL 19.91 Feet	TMP 91.06 Deg.F	BAT 13.6 V	450.0 GPM	229,990,000 GAL
Yukon Well #5						LVL 6.5 Feet	TMP 91.06 Deg.F	BAT 13.6 V	0.0 GPM	111,715,000 GAL
Jackrabbit L.S. #1							TMP 100.48 Deg.	BAT 13.6 V		
Cruizer L.S. #2		P2R					TMP 95.77 Deg.F	BAT 13.8 V		
N. Pacific L.S. #3							TMP 102.05 Deg.	BAT 13.7 V		
Pen. Bridge L.S. #5						LVL 4.67 Feet		BAT 13.73 V	0.0 GPM	4,303,000 GAL
Pen. Bridge LS Fl #1									0.0 GPM	7,976,000 GAL
Pen Bridge LS Fl #2									0.0 GPM	7,471,000 GAL
Trk Stop L.S. #6						LVL 3.61 Feet		BAT 13.59 V	0.0 GPM	0 GAL
Powers L.S. #4						LVL 2.25 Feet		BAT 13.67 V	0.0 GPM	8,000 GAL
I/P Pumps						LVL 2.19 FT	LVL 12.12 FT			
Transfer Pumps						FR 0.0 GPM				
Irrigation Pump	IPC	IPR				IFR 528.43 GPI				
WWTP Alarms						RFR 0.0 GPM				
Centrifical Blowers	B1R					RSF 400.74 GPI				
Floating Aerator 1-7										
Floating Aerator8-13										
FloatingAerator14-19										
FloatingAerator20-24										

4.4.2 Automated Control

Additionally, the system allows automated controls for the water tower and four wellheads within the City's wellfield (East, Broadway, Park and Shop Wells), shown in the SCADA "human-machine interface" (HMI) on the following page. The HMI for the City's SCADA system is physically located and monitored at the City Shop.



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4.4.3 Security

Through Ultra-VNC software, the existing SCADA information is accessible via internet connection with a username and password. Currently, other than this username and password, virtually no security system in place to protect the City's existing SCADA information. Additionally, the existing username and password are relatively generic and therefore easily decoded by modern hacking software. The existing configuration leaves the City's SCADA system and network vulnerable to hacking. A new SCADA system would be set up using a VPN connection to the network, adding layers of security and protection for the City's SCADA information and network.

4.4.4 SCADA Upgrades

To provide the most effective strategy moving forward for the City, AE2S recommends the development of a SCADA Master Plan to identify the City's needs, desires and best long-term approach to SCADA. A typical SCADA Master Plan would include the following:

- A Kickoff Meeting with City water and wastewater staff to gather input on needs
- Perform a full review of the existing control system and associated instrumentation
- Work in conjunction with City staff to determine required and recommended level of control system functionality and performance
- Establish control system alternatives and estimated costs for system improvements
- Review potential improvement strategies with the City to finalize direction
- Provide a SCADA Master Plan report detailing the chosen improvement approach, along with updated opinions of probable costs.

Once the SCADA Master Plan is approved and accepted, the City could implement the improvements comprehensively, or in a phased approach.

5.0 FUTURE DESIGN CRITERIA AND CONDITIONS

Design conditions regarding hydraulic flows, nutrient and organic loading and disposal rates have been defined to ensure all proposed alternatives will provide sufficient capacity to serve the City of Belgrade for a 20-year design life. This chapter describes the methodology behind establishing the future design conditions.

5.1 Hydraulic Flows

Data from a variety of sources was referenced to determine the most appropriate design flows. Historic treatment plant inflow data was considered in conjunction with metered water usage data, Belgrade's pervious system upgrade design conditions, population estimates and industry standards. The applied rationale is presented in the sections to follow.

5.1.1 Population

As detailed in Chapter 2, population data from the United States Census Bureau was used to evaluate population trends for both the City of Belgrade and Gallatin County. Through that process, an annual growth rate of 3.5% was recommended to project future populations. The City approved the proposed growth rate in an e-mail from the City Planner's office on October 24, 2016. The aforementioned email is provided in Appendix 2.

Table 5-1 reiterates the populations originally presented in Chapter 2. US Census data was used to estimate yearly populations from 2010 to 2014. The approved growth rate of 3.5% was used to estimate populations from 2015 to the design year of 2038. These population estimates will be referenced to establish the per capita wastewater production rate and project future flows.

Table 5-1
Population Estimate Summary

Year	Population (persons)
2010	7,389
2011	7,489
2012	7,591
2013	7,693
2014	7,798
2015(1)	8,071
2016(1)	8,353
2020(1)	10,423
2030(1)	14,703
2038(1)	19,360

(1) Estimated with approved 3.5% annual growth rate

5.1.2 Wastewater Data

Treatment plant influent data from the City's SCADA system was referenced for an initial evaluation of the City's wastewater production rate. As previously discussed in Chapter 3, the influent flow meter's accuracy is questionable. Recorded flow rates from October 2014 to January 2015 showed a dramatic spike. Conversations with City staff indicated that the influent flow meter had been damaged and was not properly seated in the control structure. The City replaced the damaged meter. In preparation for this Master Plan, M.E.T. Controls and Automation was hired to verify the accuracy of the BWTP's flow meters. It was determined that the new influent flow meter was not the recommended type for open channel volumetric flow measurements. Additionally, system variables such as pipe slope were entered into the meter's software with incorrect information. This resulted in elevated flow measurements.

In order to assess the applicablility of the available SCADA influent data, recorded average flow rates were compared to population data to define a wastewater production rates. Production rates average 88.8 gpcd from 2014 to 2016. Although this number is believed to be high due to meter inaccuarcies, it is considered reasonably but not inorbanantly conservative.

5.1.3 Inflow and Infiltration (I/I)

Inflow and infiltration (I/I) may add to the overall wastewater flow, artificially elevating wastewater production rates. Seasonal fluctuations in flow rates are tyipcal of systems experiencing significant I/I. Chart 5-1 graphically displays the monthly average flow rates. No obvious seasonal trend is present. As mentioned previously in this Master Plan, the groundwater table is more than 20 feet below the ground surface in and around Belgrade. As such, the City's sanitary sewer system is significantly above the water table and is not believed to experience consequential amounts of I/I.

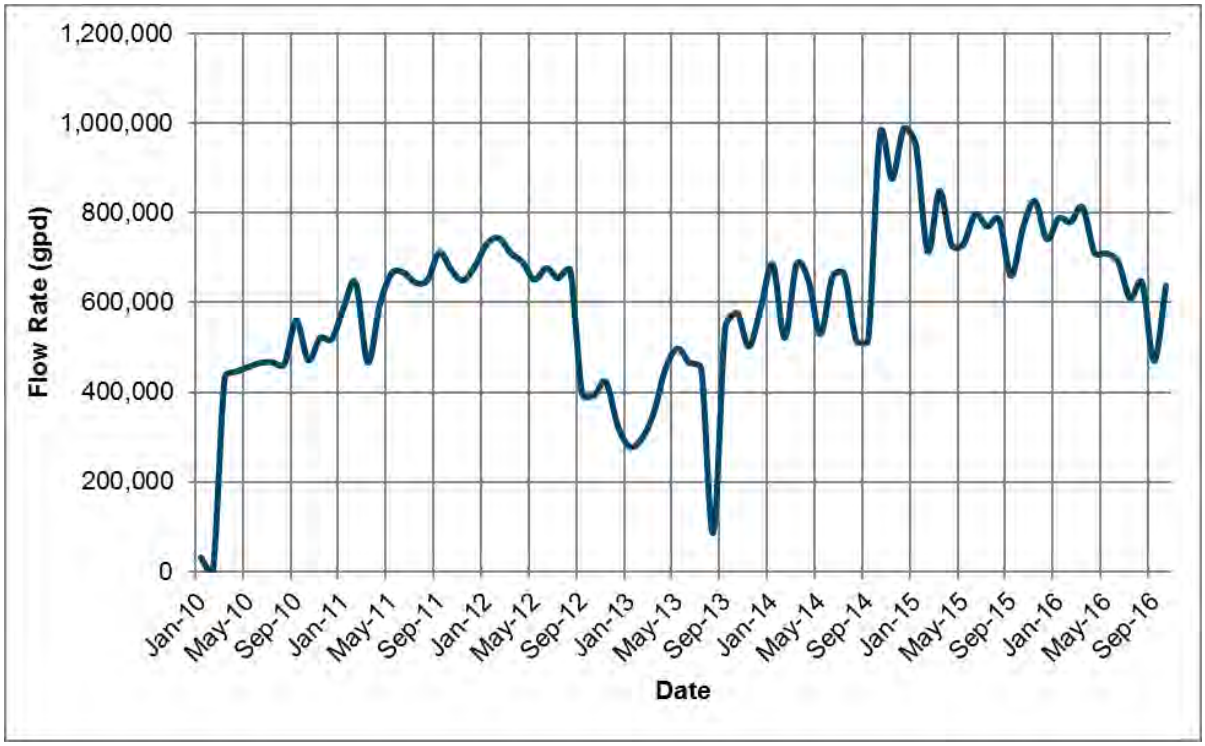


Chart 5-1: Historic Monthly Average Day Flows

5.1.4 Water Usage Data

Water usage data has historically been used to estimate wastewater flow when measured records are not available. While the City of Belgrade does monitor lagoon influent rates, water data is also available and therefore was considered as a secondary means of estimating wastewater production rates.

Water usage data is available in two forms: water well production data and metered water sale records. Water usage rates for the winter months (November to March) were calculated for January 2013 to December 2015 using estimated yearly populations previously discussed. In order to eliminate water usage which does not discharge to the sewage system, such as car washing and lawn irrigation, the spring, summer and fall months were excluded from the analysis. Table 5-2 reports calculated water usage rates. Raw water usage data is available in electronic form in the Appendix. Average water usage calculations are provided in Appendix 5.

Table 5-2
Average Water Usage (gpcd)

Month	2013	2014	2015
January	92.0	75.3	65.1
February	73.0	75.5	71.3
March	69.0	64.4	68.0
November	65.2	67.8	68.1
December	76.5	83.0	85.7
Winter Months Average	***75.1***	***73.2***	***72.0***

Data presented in Table 5-2 was obtained from the municipal well meters and individual service meters. These meters are considered to be operating properly and providing reliable data. The average winter month water production rates for 2014 and 2015 are roughly 17% and 25% less than the average wastewater production rates reported in Table 5-2. The elevated wastewater production relative to the water usage is not likely caused by I/I, as previously discussed. It may be explained by unmetered water customers and any residential home or business with private drinking water wells that utilize the public sewer system. However, the most likely cause is the elevated influent wastewater data caused by meter error, as previously mentioned.

5.1.5 Previous Design Conditions

The original Facilities Plan, prepared in 1997, calculated an average wastewater production rate of 86 gpcd for the City of Belgrade. This was based on a series of flow measurements taken from the BWTP inlet and the airport from December of 1993 and January of 1994.

The wastewater production rate was reevaluated in October 2001 for the Wastewater Treatment Facility and Outfall Sewer Design Report. Flow measurements were taken for 11 consecutive days at the outfall sewer. Based on the data reported in the 2000 Census, the average recorded flow equated to 88.5 gpcd. Based on an estimated 2001 population, the average flow was equivalent to 85.1 gpcd. These values confirmed that 86 gpcd remained appropriate for estimating future flows in the Belgrade area. Additionally, the 2001 Design Report noted sewer flows averaged about 15.5 % higher than average water use from December 2000 to February 2001. At that time, it was believed that some dwellings and businesses had private water wells

but still utilized the public sewer system. Additionally, City staff have indicated the Airport has been known to require more water than previously believed.

5.1.6 DEQ Standards

Circular DEQ-2 Design Standards for Public Sewage Systems, published in 2016, provides guidance for sizing wastewater facilities. Section 11.243.a recommends 100 gpcd for projecting future design flows, unless water use data or other justification upon which to better estimate flow is available.

5.1.7 City of Belgrade Design Standards

The City of Belgrade published a new Design Standards and Specification Policy in 2017. The Policy states, "New sanitary sewer lines to serve residential area shall be designed to accommodate an average daily flow rate of 90-gallons per capita per day. An infiltration rate of 50-gallons/acre/day shall be added to all flow calculations when designing new sewers." The policy indicates in non-residential areas, new sanitary sewer lines are to be designed to accommodate 140 gpd per person within the corresponding land use zone. The equivalent population per land use zone is provided as persons per acre and is available in the Belgrade Design Standards and Specification Policy. The Policy also indicates that gravity sewers shall be designed to flow no more than 75% full at peak hour design flows at full build-out.

5.1.8 Design Flows

Current wastewater production and water usage rates remain relatively consistent with previous evaluations for the City of Belgrade. Although meter error is believed to cause elevated wastewater production rates, it is recommended to maintain the design wastewater production rate of 86 gpcd for reasonably conservative flow projections. Population projections discussed previously were used in conjunction with 86 gpcd to estimate treatment lagoon design flows. Population was projected over the 20-year planning period ending in 2038. The City of Belgrade's population in 2038 is projected to be 19,360 persons. This equates to a treatment facility design flow of 1,670,000 gpd.

Peaking factors calculated from available SCADA data for maximum month, maximum day, peak hour and peak instantaneous flow were detailed in Chapter 3. It was determined that the peak factors for maximum month, maximum day, peak hour and peak instantaneous flows are 1.44, 1.99, 3.30 and 4.19, respectively. Used in conjunction with the projected average day flow, these peaking factors result in a projected maximum month flow of 2,404,808 gpd, a maximum day flow of 3,323,300 gpd and peak hour and instantaneous flows of 5,511,000 gpd and 6,997,330 gpd, respectively. This information is summarized in Table 5-3.

Table 5-3 Design Flows		
Flow Type	**Peaking Factor**	**Design Flow (gpd)**
Average Day	-	1,670,000
Maximum Month	1.44	2,404,800
Maximum Day	1.99	3,323,300
Peak Hour	3.30	5,511,000
Peak Instantaneous	4.19	6,997,300

Future collection system improvements will be designed using the City of Belgrade design standards and the projected zoning. These flows are defined and discussed in greater detail in Chapter 6.

5.2 Organic Loading

5.2.1 Treatment Plant Influent Nutrient and Organic Loading

The design nutrient and organic loading into the BWTP is based on historic pollutant concentrations in the raw wastewater. Monthly samples have been collected and sent to analytical laboratories for analysis. Water quality data from November 2013 to December 2016 was averaged and multiplied by the projected average day flow to determine design organic loading. Raw data is provided in Appendix 4. Table 5-4 defines the BWTP's design loading criteria.

Table 5-4 Treatment Plant Design Influent Nutrient and Organic Loading		
Pollutant	**Concentration (mg/l)**	**Average Day Loading (ppd)**
BOD	407.7	5,689
TSS	271.3	3,786
Ammonia	34.3	479
Nitrate + Nitrite	0.5	7
TKN	63.0	879
TN	63.5	886
TP	8.1	113

5.2.2 Treatment Plant Effluent Nutrient and Organic Loading

Effluent design criteria were calculated under the assumption that the City's current TN loading limits to the existing IP beds would remain at current limits in future permits. This assumption is based on conversations with the DEQ during a February 8, 2017 meeting and subsequent correspondence. Meeting notes and e-mail correspondence regarding the City's discharge permit are included in Appendix 5.

The design effluent TN concentration was calculated using a simple water balance for the treatment plant. The allowable nitrogen loading in the discharge permit is presumed to remain constant for future permit cycles. Since the groundwater monitoring wells have rarely indicated exceedance of permit values, it seems reasonable to assume the loading limits for Nitrogen will not decrease in the future. The influent flow rate was defined by the design average day flow of 1.67 MGD. Agronomic rates defined in the 2002 Spray Irrigation Design Report were used to calculate monthly discharge volumes to the irrigation system. Monthly discharge volumes to the three IP beds were assumed to be equivalent among all three existing beds. IP bed discharge volumes were calculated so that cumulative storage within Lagoon #3 is equal to 0.0 gallons at the end of September; meaning the storage lagoon will drain at the end of the irrigation season. Estimated discharge volumes to the three IP beds were then referenced with TN loading limits to calculate the maximum allowable effluent TN concentration. A 10% safety factor was applied; **the design effluent TN concentration for the BWTP is 13.5 mg/l.** Detailed calculations are provided in Appendix 5.

To remain compliant with DEQ standards, the City will also need to achieve 85% TSS and BOD removal in all proposed upgrades. No permit limits have been set on effluent phosphorous concentrations.

5.3 Disposal Rates

Design disposal rates and required storage volume will be specific to each disposal alternative described in Chapter 7. The maximum allowable discharge flow rates based on IP bed available hydraulic capacity and calculated agronomic rates are detailed in the following sections.

5.3.1 IP Bed Hydraulic Loading

The design IP bed hydraulic loading was calculated based on Circular DEQ-2 design criteria, existing IP bed characteristics and the allowable total nitrogen loading. An infiltrometer test performed for the 2004 Design Report found the most restrictive soils layer in the area consisted of sandy gravel soil and reported an infiltration rate of 0.25 inches/min. Circular DEQ-2 recommends using 7-10% of the measured infiltration rate for IP bed design. To ensure a conservative design, 7% of the measured rate, 0.0175 inches/min, was applied to the design criteria calculations. As discussed in Chapter 4, each of the three IP beds consists of 5 cells. The cells are approximately 100 feet by 200 feet and provide 20,000 SF of infiltration area per cell, or 100,000 SF per bed. Based on measured infiltration rates, the maximum allowable flow rate into each cell is 314,000 gpd, or 1,571,000 gpd into each IP Bed.

Varying wetting and drying periods are recommended for winter and summer months. Circular DEQ-2 suggests applying the treated wastewater to the cells for 1 to 3 days followed by 4 to 5 days of drying time during summer months. For the winter months, an application period of 1 to 3 days followed by 5 to 10 days of drying is suggested. To remain conservative, the summer application and drying periods are assumed to be 3 and 5 days, respectively. The winter application period is 3 days and the drying period is 10 days. Based on the calculated maximum allowable application rate of 1,571,000 gpd per IP bed and the assumed application and drying periods, the allowable average day discharge to each of the IP beds in the summer is 589,000 gpd and 362,000 gpd in the winter months. With the design TN effluent concentration of 13.5 mg/l, the average day TN loading to each bed in the summer months is estimated at 66.5 ppd and 40.9 ppd in the winter months. This is in accordance with the current

permit's limits on maximum average day loading per month. Calculations provided in Appendix 5.

5.3.2 Agronomic Rates

Design agronomic rates were calculated assuming a TN effluent concentration of 13.5 mg/l. Precipitation and evaporation data was downloaded from the Bozeman-Yellowstone International Airport's weather station. Soil data was taken from the Web Soil Survey provided by the United States Department of Agriculture (USDA) NRCS. Crop uptake values utilized in the Morrison Maierle, Inc. 2002 design were assumed for the future agronomic rates. Table 5-5 summarizes the design agronomic rates; detailed calculations are provided in Appendix 5.

Table 5-5
Design Agronomic Rates

Month	Irrigation Days	Application Rate (inches)
May	15	6.73
June	30	13.73
July	31	19.11
August	31	17.76
September	15	9.15

The maximum allowable average day disposal rates to the irrigation system are defined below in Table 5-6. These rates were calculated based on the 117 acres of irrigation land currently available to the City and the irrigation days and agronomic rates defined in Table 5-5.

Table 5-6
Design Irrigation Flow Rates

Month	Rate		
	(inches)	(gallons)	(gpd)
May	6.73	21,382,930	1,425,529
June	13.73	43,623,718	1,454,124
July	19.11	60,717,353	1,958,624
August	17.76	56,428,058	1,820,260
September	9.15	29,071,888	1,938,126
October	0.00	0	0
Annual	**66.48**	**211,223,946**	**1,731,344**

5.4 Miscellaneous

Concerns regarding large water surface areas were expressed by the Federal Aviation Administration (FAA) and the Gallatin County Airport in response to the 1998 Belgrade Wastewater Treatment Facility Plan. A Facility Plan Amendment was published in 2000 to address concerns with the surface water attracting water fowl to the area. An elevated waterfowl population increases the risk of aircraft strikes. To minimize these risks, efforts are to

be taken to limit the total water surface area of any of the proposed improvements under consideration.

Additionally, all improvements will comply with all applicable state and federal regulations. All final designs will abide by Montana Public Works Standard Specifications (MPWSS) and generally accepted engineering practices.

6.0 COLLECTION SYSTEM ALTERNATIVE EVALUATION

Chapter 6 identifies the recommended sewer collection system improvements for both future development and existing infrastructure. This chapter estimates demands in areas of future growth, proposes improvements to serve future growth, and evaluates the impacts to existing infrastructure. Calculations are provided in Appendix 6. In addition, the chapter will summarize existing deficiencies in the collection system. All recommendations were prepared prior to June 2017 and may not reflect recent construction or development in the planning regions.

6.1 FUTURE GROWTH AND DEVELOPMENT

The areas of future growth between the City limits and planning boundary were identified and delineated through discussions with City personnel and by reviewing property ownership and aerial imagery. Seven future planning regions were delineated and referenced to develop design flow rates, gravity trunk main sizing, lift station location, and force main diameter. Table 6-1 presents the nominal capacity of gravity mains at DEQ-required minimum slopes and at two flow depths. No costs were developed for the planning regions since, in most cases, it is difficult to predict when the development will occur and how costs may be distributed between the City and the developer.

Table 6-1
Gravity Sewer Capacity at Minimum Slope

Sewer Diameter	DEQ Minimum Slope (ft/ft)	City Design Criteria 75% Full		90% Full	
		Flow Rate (gpm)	Velocity (ft/s)	Flow Rate (gpm)	Velocity (ft/s)
6-inches	0.0060	178	2.5	210	2.4
8-inches	0.0040	313	2.5	369	2.4
10-inches	0.0028	474	2.4	560	2.3
12-inches	0.0022	684	2.4	807	2.3
15-inches	0.0015	1,024	2.3	1,208	2.3
18-inches	0.0012	1,489	2.3	1,757	2.3
21-inches	0.0010	2,051	2.4	2,419	2.3

The planning regions do not include all parcels between the City limits and the future planning boundary. Figure 6-1 identifies the planning regions and the zoning. Property owned by the Gallatin Airport Authority (GAA), labeled in Figure 6-1, is not included in the planning regions; future development on GAA property will be accomplished through private wastewater conveyance. Finally, parcels exist within the planning area that were previously developed as private homes, businesses, or subdivisions. It is not expected that land owners would pay to connect to the City's system considering their previous investment in DEQ-approved private water and sewer systems.

The design peak hour flow for each future development region was estimated by applying the City's design standards and the mapped zoning. Lift station and force main sizing was based on peak hours flows. Gravity mains were sized using the City's "75% full" standard at the design peak hour flow; during design, gravity mains should be designed based on their contributing tributary area, not the peak hour flow in the planning region. Sewer main lengths are conceptual

and represent the sewer interceptors in the planning regions; smaller collector mains were not considered in this Master Plan. Calculations are provided in Appendix 6. Pipe sizing is not intended to be final; local conditions, primarily topography and final routing, may affect gravity main sizing and should be considered during design.

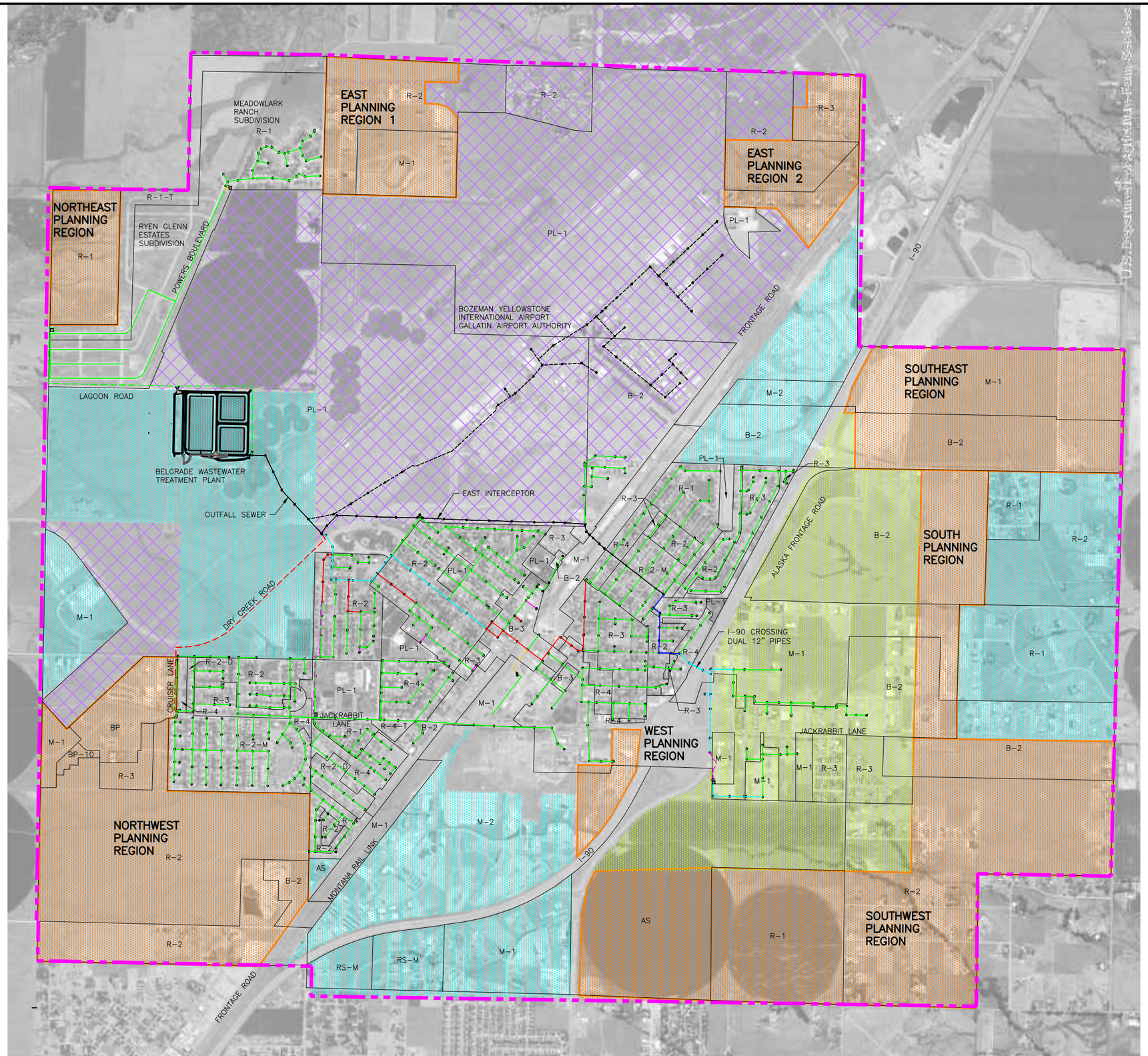
6.1.1 Northwest Planning Region

The northwest region consists of multiple parcels totaling 523 acres. The parcels are located west and north of the Cruiser Lift Station. The region is zoned for M-1, BP-10, BP, R-2, and R-3. The estimated peak hour flow, calculated from the mapped zoning, is 2,024 gpm; however, unlike the other planning regions, significant preparation for improvements in the region is already underway. As a result of those efforts, a local design flow was estimated from design reports for two proposed subdivisions and conservative zoning changes not depicted in Figure 6-1. In addition, the planning efforts include provisions to receive wastewater from the existing Cruiser Lift Station. The resulting ultimate design flow in the northwest planning region is 2,664 gpm (3.83 MGD). The ultimate design flow calculations are provided in Appendix 6.

Preliminary planning efforts in the northwest region propose the following improvements:

- A Northwest Regional Lift Station which would receive wastewater from the planning region and the Cruiser Lift Station.
- A temporary lift station in the Henson subdivision, north of Cruiser Lane, to serve the Henson Phase I subdivision. The station would eventually be abandoned after construction of the Northwest Regional Lift Station.
- Improve the Cruiser Lift Station according to the recommendations in Chapter 3 and install a short force main to facilitate conveyance to the Northwest Regional Lift Station.
- The recommended gravity trunk main, assuming minimum DEQ slopes, is 27 inches in diameter.
- The recommended force main from the Northwest Regional Lift Station is 12 inches in diameter.

The description and analysis of future wastewater infrastructure in the northwest planning region are more detailed than other planning areas as a result of independent studies prepared by TD&H Engineering and developer consultants. The following sections provide background information from those efforts and summarize the status of the planned improvements. Preliminary planning documents from the subdivision developers, the City, and TD&H are provided in Appendix 6. Figure 6-2 presents an overview of the planning region and the proposed improvements.



LEGEND

- PROPOSED PLANNING AREA BOUNDARY
- 6" SANITARY SEWER
- 8" SANITARY SEWER
- 10" SANITARY SEWER
- 12" SANITARY SEWER
- 18" SANITARY SEWER
- 21" SANITARY SEWER
- SANITARY SEWER – SIZE UNKNOWN
- 4" FORCEMAIN
- 6" FORCEMAIN
- 8" FORCEMAIN
- 10" FORCEMAIN
- SEWER MANHOLE (NOT ALL SHOWN.)
- EXISTING LIFT STATION
- ZONING BOUNDARY
- PLANNING REGIONS
- SID #78 FUTURE PLANNING AREA
- EXISTING DEVELOPMENT OUTSIDE CITY LIMITS
- GALLATIN AIRPORT AUTHORITY PROPERTY

0 1000' 2000' 3000'
SCALE

ZONING INDEX

ZONE	DESCRIPTION
AS	Agricultural Suburban District
BP	Business Park
BP-10	Business Park
B-2	Highway Business District
B-3	Central Business District
M-1	Commercial-Light Manufacturing District
M-2	Manufacturing and Industrial District
PL-1	Public Lands and Institutions
R-1	Residential Single Family
R-1-T	Residential Transitional District
R-2	Residential Single Family District Medium Density
R-2-D	Residential One and Two Family
R-2-M	Residential Single Family and Manufactured Homes
R-3	Residential Medium Density District
R-3-Multi	Residential Multi-Family District
R-4	Residential Apartment District
R-4-1	Residential Transitional District
RS-M	Residential Suburban Manufactured

NOT FOR CONSTRUCTION

REV	DATE	REVISION

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1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY: CEVJ
DESIGNED BY: CEVJ/DDN
QUALITY CHECK:
DATE: 2017-06-20
JOB NO. B16-048
FIELDBOOK

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

PLANNING REGIONS

FIG 6-1.DWG
FIGURE 6-1

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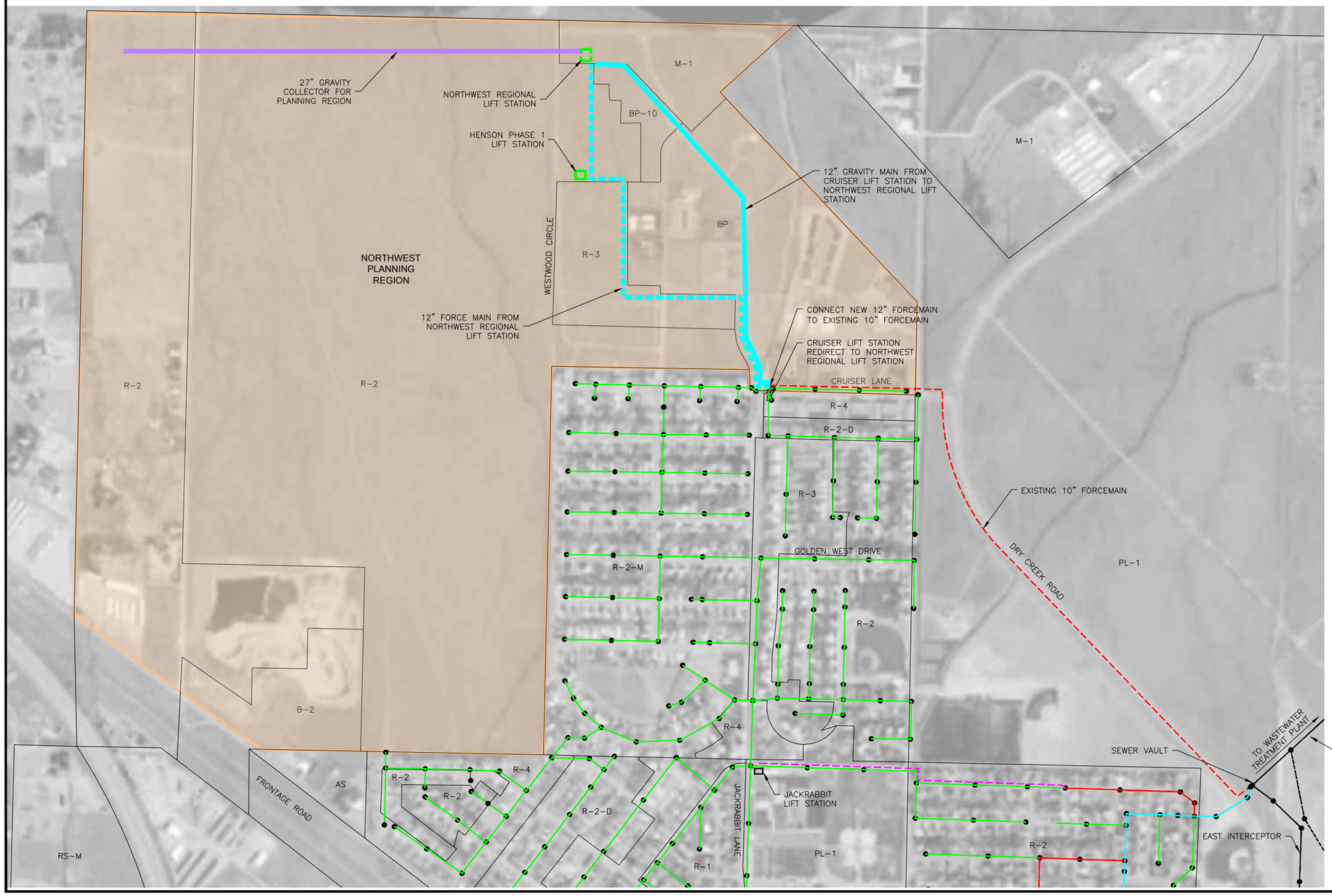
J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 6-2.dwg, 3/9/2018 3:13:02 PM, CEJ



LEGEND

PROPOSED	EXISTING	
		6" SANITARY SEWER
		8" SANITARY SEWER
		10" SANITARY SEWER
		12" SANITARY SEWER
		15" SANITARY SEWER
		18" SANITARY SEWER
		21" SANITARY SEWER
		24" AND LARGER SANITARY SEWER
		SANITARY SEWER – SIZE UNKNOWN
		4" FORCEMAIN
		6" FORCEMAIN
		8" FORCEMAIN
		10" FORCEMAIN
		12" FORCEMAIN
		ZONING BOUNDARY
		SEWER MANHOLE (NOT ALL SHOWN.)
		LIFT STATION
		PLANNING REGION

ZONING INDEX

ZONE	DESCRIPTION
AS	Agricultural Suburban District
BP	Business Park
BP-10	Business Park
B-2	Highway Business District
B-3	Central Business District
M-1	Commercial-Light Manufacturing District
M-2	Manufacturing and Industrial District
PL-1	Public Lands and Institutions
R-1	Residential Single Family
R-1-T	Residential Transitional District
R-2	Residential Single Family District Medium Density
R-2-D	Residential One and Two Family
R-2-M	Residential Single Family and Manufactured Homes
R-3	Residential Medium Density District
R-3-Multi	Residential Multi-Family District
R-4	Residential Apartment District
R-4-1	Residential Transitional District
RS-M	Residential Suburban Manufactured

NOTE:
PROPOSED SANITARY SEWER LAYOUTS ARE PRELIMINARY AND SHOULD BE EVALUATED DURING DESIGN.

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REV	DATE	REVISION

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234 E. BABCOCK ST., SUITE 3 • BOZEMAN, MONTANA 59715

DRAWN BY: CJS
DESIGNED BY: CEVJ/DDN
QUALITY CHECK:
DATE: 2018-03-09
JOB NO. B16-048
FIELDBOOK

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

NORTHWEST PLANNING REGION PROPOSED IMPROVEMENTS

FIG 6-2.DWG

FIGURE 6-2

6.1.1.1 Proposed Subdivisions

The northwest planning region includes two proposed subdivisions: Henson and DLM/Prescott. Preliminary documents indicate the Henson subdivision will be constructed in three phases.

As mentioned in Chapter 3, new gravity mains, a lift station, and force main are planned for the Henson Phase I subdivision. The gravity mains and lift station are intended to serve Phase I of the new subdivision; however, the new force main will be sized to accommodate the proposed Northwest Regional Lift Station. Construction of the Henson Phase I improvements are expected to begin in June 2017; however, at the time of this report preparation, final design of the new force main is not complete. The peak hour design flow in the Henson Phase I subdivision is 175 gpm (0.25 MGD).

The DLM/Prescott subdivision is currently in the planning stages. Design flows submitted by the developer indicate aggressive growth in the subdivision, resulting in peak hour flows of 705 gpm (1.02 MGD) at full buildout.

6.1.1.2 Northwest Regional Lift Station

The proposed Northwest Regional Lift Station is expected to eventually replace the Henson Phase I Lift Station. An analysis of the proposed regional lift station capacity was completed by TD&H Engineering exclusive of this Master Plan; however, at the time, the "event log" analysis was not complete at the Cruiser Lift Station, so the nominal pump capacity was assumed to equal the peak hour flow. Those preliminary calculations should be revised to account for the updated ultimate peak hour flow, or 2,664 gpm. A submersible triplex station with three identical pumps is proposed. Based on the new peak hour flow, each pump should convey 1,335 gpm. Triplex stations require larger wet wells and valve vaults to accommodate the piping and pumps. It is recommended to construct a controls/generator building to house the backup generator and control panels.

6.1.1.3 Cruiser Lift Station Improvements

In addition to the repairs and improvements recommended at the Cruiser Lift Station in Chapter 3, the station will eventually require a redesign to convey wastewater to the Northwest Regional Lift Station. It is proposed to minimize the size of any new pumps by redirecting the Cruiser Lift Station flows to a new 12-inch gravity main in Jackrabbit Lane. A short 6-inch force main is necessary to elevate raw wastewater and permit gravity flow to the proposed regional lift station.

Originally, it was proposed to abandon the Cruiser Lift Station in favor of conveying all the flows by gravity to the proposed Northwest Regional Lift Station; however, the sewer manholes in the vicinity were recently revealed to be quite deep. Sections of piping are 13 to 15 feet below grade. It may not be feasible to design and construct deep gravity mains from Cruiser Lane to the proposed location of the Northwest Regional Lift Station; therefore, it is proposed to install new pumps and force main to discharge to a manhole a short distance from the Cruiser Lift Station in Jackrabbit Lane.

Coordinating the design and construction of the various components at the Cruiser Lift Station and the proposed Northwest Regional Lift Station will require cooperation between

developers and the City. In the interim, the City will be required to continue to maintain and repair the Cruiser Lift Station until the new regional lift station is operational.

6.1.1.4 Impacts to Existing Infrastructure

Development in the northwest planning region will affect the Cruiser Lift Station, the 10-inch force main in Dry Creek Road, and the Outfall Sewer. The capacity of the Outfall Sewer is discussed in the following sections. The 10-inch force main will exceed recommended velocities when the Northwest Regional Lift Station is constructed. The velocity is estimated at slightly greater than 10 ft/sec, above both DEQ's and the EPA's maximum velocity recommendations. It is recommended to request a deviation from Montana DEQ; however, if a deviation is not granted, then the force main must be upsized. Effects to the Cruiser Lift Station were previously discussed.

6.1.2 Northeast Planning Region

The northeast planning region consists of a single 82-acre parcel located north of the Ryen Glenn Estates subdivision. The parcel is zoned as R-1 and the estimated peak hour flow is 308 gpm. The ground generally slopes to the north; sewer flows can be expected to flow by gravity to the existing Ryen Glenn Lift Station. An 8-inch trunk main will be necessary to convey ultimate buildout flows to the lift station. The length of the trunk main will vary depending on the configuration of future growth or subdivision; however, the length could range from 1,500 LF to 2,500 LF. Smaller collector gravity mains will also be required throughout the planning region. Figure 6-3 presents the proposed improvements in the planning region. Development in the northeast planning region will affect the Ryen Glenn Lift Station and force main. These impacts will be discussed in Section 6.2.

ZONING INDEX

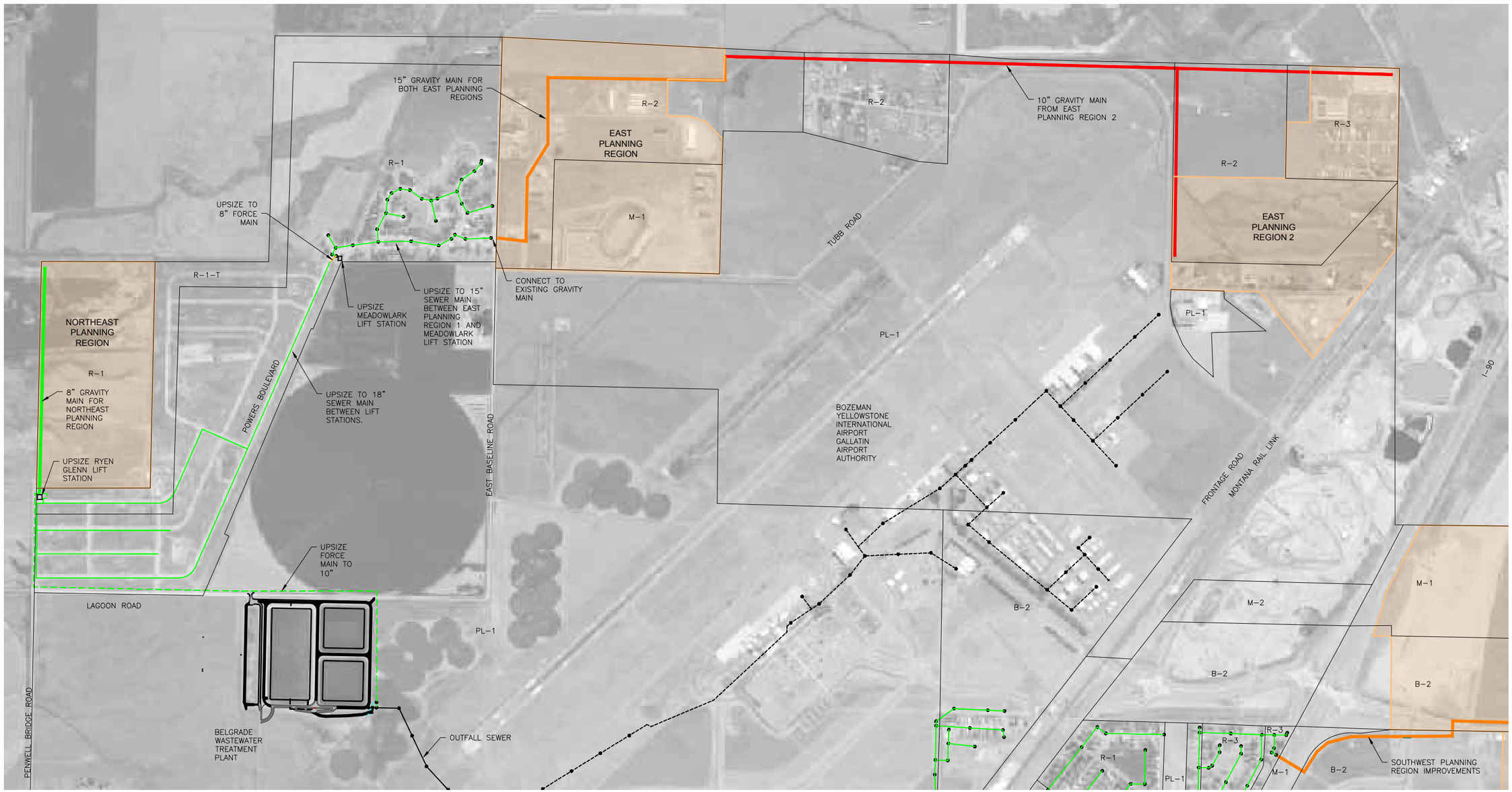
ZONE	DESCRIPTION	ZONE	DESCRIPTION
AS	Agricultural Suburban District	R–3	Residential Medium Density District
BP	Business Park	R–3–Multi	Residential Multi–Family District
BP–10	Business Park	R–4	Residential Apartment District
B–2	Highway Business District	R–4–1	Residential Transitional District
B–3	Central Business District	RS–M	Residential Suburban Manufactured
M–1	Commercial–Light Manufacturing District		
M–2	Manufacturing and Industrial District		
PL–1	Public Lands and Institutions		
R–1	Residential Single Family		
R–1–T	Residential Transitional District		
R–2	Residential Single Family District Medium Density		
R–2–D	Residential One and Two Family		
R–2–M	Residential Single Family and Manufactured Homes		

NOTE:
PROPOSED SANITARY SEWER LAYOUTS ARE PRELIMINARY AND SHOULD BE EVALUATED DURING DESIGN.

0 600' 1200' 1800'
SCALE

LEGEND

PROPOSED	EXISTING	
		6" SANITARY SEWER
		8" SANITARY SEWER
		10" SANITARY SEWER
		12" SANITARY SEWER
		15" SANITARY SEWER
		18" SANITARY SEWER
		21" SANITARY SEWER
		24" AND LARGER SANITARY SEWER
		SANITARY SEWER – SIZE UNKNOWN
		4" FORCEMAIN
		6" FORCEMAIN
		8" FORCEMAIN
		10" FORCEMAIN
		12" FORCEMAIN
		ZONING BOUNDARY
		SEWER MANHOLE (NOT ALL SHOWN.)
		LIFT STATION
		PLANNING REGION



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DATE: 2018-03-09
JOB NO. B16-048
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BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

NORTHEAST AND EAST PLANNING REGIONS PROPOSED IMPROVEMENTS

FIG 6-3.DWG
FIGURE 6-3

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 6-3.dwg, 3/9/2018 3:17:28 PM, CEJ

6.1.3 East Planning Regions

The east planning regions are located south of the Meadowlark Ranch subdivision, adjacent to Gallatin Airport Authority property. The east regions are divided by GAA property: East Region 1 is 155 acres with a peak hour flow of 456 gpm (0.66 MGD) and East Region 2 is 125 acres with a peak hour flow of 402 gpm (0.58 MGD). The areas are zoned for R-1, R-2, R-3, PL-1, and M-1; the total peak hour flow is 858 gpm (1.24 MGD). According to the USGS National Elevation Dataset (NED), the east regions are located upgradient from both the Meadowlark Ranch and Ryen Glenn Estates subdivisions; therefore, it is proposed to route both regions to the Meadowlark Ranch sewer system. A 10-inch diameter trunk main is proposed to convey flows from East Region 2 to East Region 1, at approximately 7,400 LF. The trunk main diameter should be increased to 15 inches, for approximately 4,500 LF, to convey both east regions to the Meadowlark Ranch subdivision. The anticipated improvements in the planning region are presented in Figure 6-3.

Development in the east region will affect infrastructure in both the Meadowlark Ranch and Ryen Glenn Estates subdivisions. The existing sewer infrastructure in the Meadowlark Ranch subdivision was designed to accommodate full build-out of the 430 subdivision lots and not necessarily from future development outside City limits. The gravity main connecting the east planning regions and the Meadowlark Lift Station must be upsized to at least a 15-inch main to accommodate the design peak hour flow in the planning region. In addition, the pumping capacity at the station is not sufficient for full build-out of the Meadowlark Ranch subdivision plus the peak flow from the east planning regions. The capacity should be increased to be equal to the peak hour flow from both areas, or:

283 gpm + 858 gpm = **1,141 gpm**.

The force main should be upsized to an 8-inch diameter pipe, resulting in a force main velocity of 7.3 ft/sec.

Impacts to the Ryen Glenn lift station and force main will be discussed in Section 6.2 in conjunction with impacts from the northeast region; however, some of the gravity mains in the subdivision will be affected by development in the east planning region. The 8-inch gravity main which conveys flows from the Meadowlark Ranch subdivision to the Ryen Glenn Lift Station does not have sufficient capacity for the estimated peak hour flow; an 18-inch gravity main is necessary to convey the peak hour demand when flowing half full.

6.1.4 Southeast Planning Region

The southeast planning region consists of several parcels south of Interstate 90. The 295-acre area is zoned B-2 and M-1, resulting in a peak hour flow of 750 gpm (1.08 MGD). The region generally slopes to the north and northeast and is not near any existing sewer infrastructure. The topography indicates it is not feasible to convey the flows to the existing SID #78 Lift Station by gravity; rather, it is proposed to convey flows from the southeast region through a new trunk main under Interstate 90. The proposed crossing would be near the recently-constructed East Belgrade Interchange – North (UPN 5897001). The trunk main would connect to existing sewer mains in Idaho Street and eventually would discharge into the sewer vault in Dry Creek Road. A single 15-inch gravity main can convey the design flow at the City's design criteria; however, it may be necessary to install two smaller, parallel mains under the interstate, similar to the existing crossing. It may be possible to install the proposed sewer main under the I-90 bridge on Alaska Road; all crossing options should be evaluated during design and should consider MDT right-of-

way concerns and accessibility. Figure 6-4 presents the proposed improvements in the southeast planning region.

Development in the southeast planning region will impact the existing 8-inch gravity mains in Idaho Street and Yellowstone Avenue. For planning purposes, the residential flows contributing to the existing sewer main in Idaho Street can be considered negligible; therefore, it is proposed to upsize the existing main to 15-inches to accommodate the peak hour flow from the planning region. Future flows in the southwest planning region will also affect the existing north-south 21-inch trunk main and the outfall sewer. The capacities of the trunk main and outfall sewer are discussed in Section 6.2.

6.1.5 South Planning Region

The south planning region consists of 132 acres adjacent to the SID #78 Lift Station planning area. It is zoned for B-2 and M-1, resulting in a peak hour flow of 445 gpm (0.64 MGD). It is proposed to connect the south planning region to existing or future sewer mains in the SID #78 planning area; flows from the south planning region would be conveyed across the interstate by the SID #78 Lift Station. A 10-inch gravity trunk main could convey the flows to the south extents of the SID #78 gravity system. The existing 8-inch mains which convey SID #78 flows to the north should be upsized to at least 10-inch pipes. Figure 6-5 presents the proposed improvements. Growth in the south region will also affect the existing I-90 crossing, the 21-inch trunk main, and the outfall sewer. The impacts to these pipes are discussed in Section 6.2.

ZONING INDEX

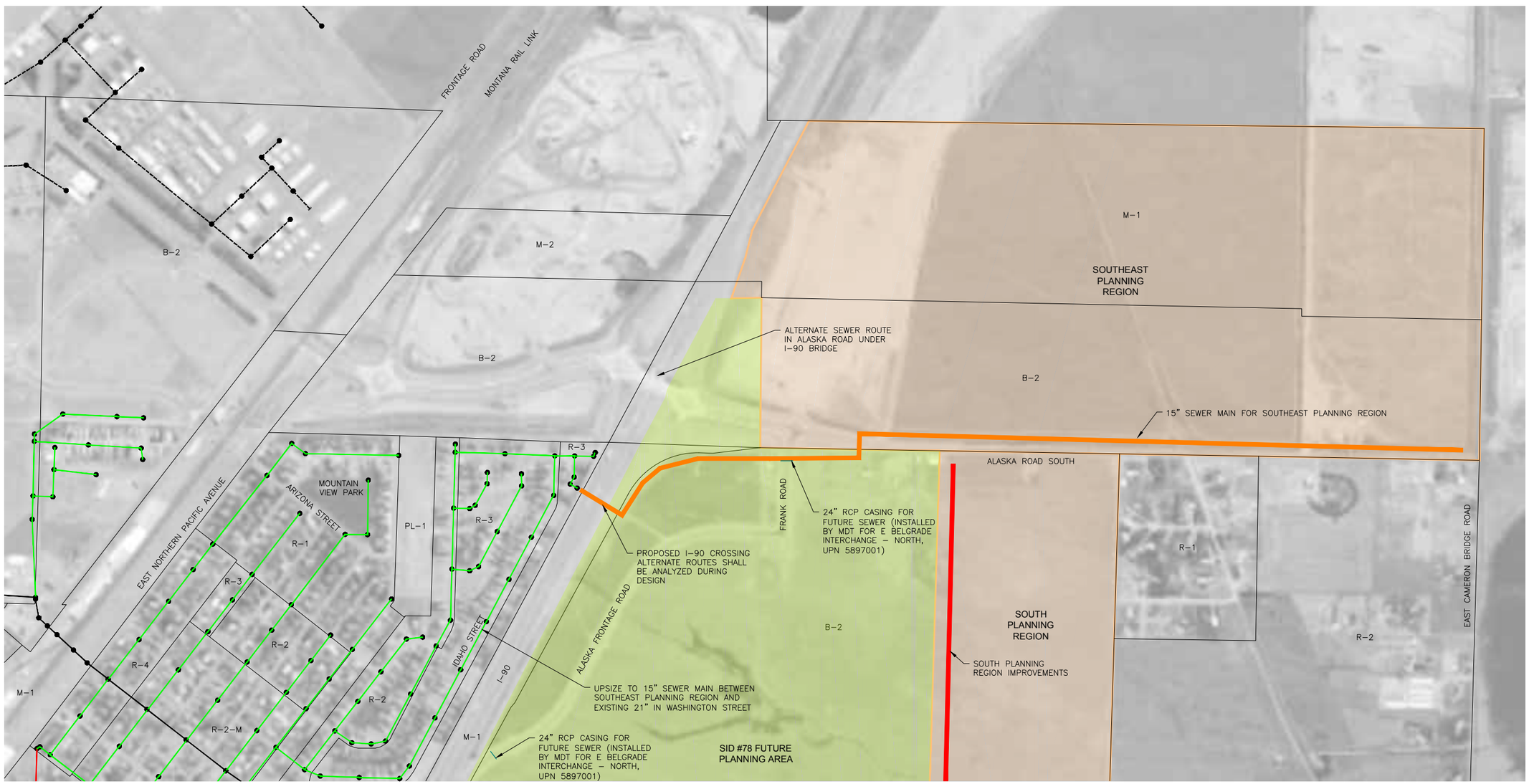
ZONE	DESCRIPTION
AS	Agricultural Suburban District
BP	Business Park
BP-10	Business Park
B-2	Highway Business District
B-3	Central Business District
M-1	Commercial-Light Manufacturing District
M-2	Manufacturing and Industrial District
PL-1	Public Lands and Institutions
R-1	Residential Single Family
R-1-T	Residential Transitional District
R-2	Residential Single Family District Medium Density
R-2-D	Residential One and Two Family
R-2-M	Residential Single Family and Manufactured Homes
R-3	Residential Medium Density District
R-3-Multi	Residential Multi-Family District
R-4	Residential Apartment District
R-4-1	Residential Transitional District
RS-M	Residential Suburban Manufactured

NOTE:
PROPOSED SANITARY SEWER LAYOUTS ARE PRELIMINARY AND SHOULD BE EVALUATED DURING DESIGN.

0 400' 800' 1200'
SCALE

LEGEND

PROPOSED	EXISTING	
		6" SANITARY SEWER
		8" SANITARY SEWER
		10" SANITARY SEWER
		12" SANITARY SEWER
		15" SANITARY SEWER
		18" SANITARY SEWER
		21" SANITARY SEWER
		24" AND LARGER SANITARY SEWER
		SANITARY SEWER – SIZE UNKNOWN
		4" FORCEMAIN
		6" FORCEMAIN
		8" FORCEMAIN
		10" FORCEMAIN
		12" FORCEMAIN
		ZONING BOUNDARY
		SEWER MANHOLE (NOT ALL SHOWN.)
		LIFT STATION
		PLANNING REGION
		SID #78 FUTURE PLANNING AREA



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DESIGNED BY: CEVJ/DDN
QUALITY CHECK:
DATE: 2018-03-09
JOB NO. B16-048
FIELDBOOK

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

SOUTHEAST PLANNING REGION
PROPOSED IMPROVEMENTS

FIG 6-4.DWG
FIGURE 6-4

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 6-4.dwg, 3/9/2018 4:07:51 PM, CEJ

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 6-5.dwg, 3/9/2018 4:18:35 PM, CEJ

LEGEND

PROPOSED	EXISTING	
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		8" SANITARY SEWER
		10" SANITARY SEWER
		12" SANITARY SEWER
		15" SANITARY SEWER
		18" SANITARY SEWER
		21" SANITARY SEWER
		24" AND LARGER SANITARY SEWER
		SANITARY SEWER – SIZE UNKNOWN
		4" FORCEMAIN
		6" FORCEMAIN
		8" FORCEMAIN
		10" FORCEMAIN
		12" FORCEMAIN
		ZONING BOUNDARY
		SEWER MANHOLE (NOT ALL SHOWN.)
		LIFT STATION
		PLANNING REGION
		SID #78 FUTURE PLANNING AREA

NOTE:
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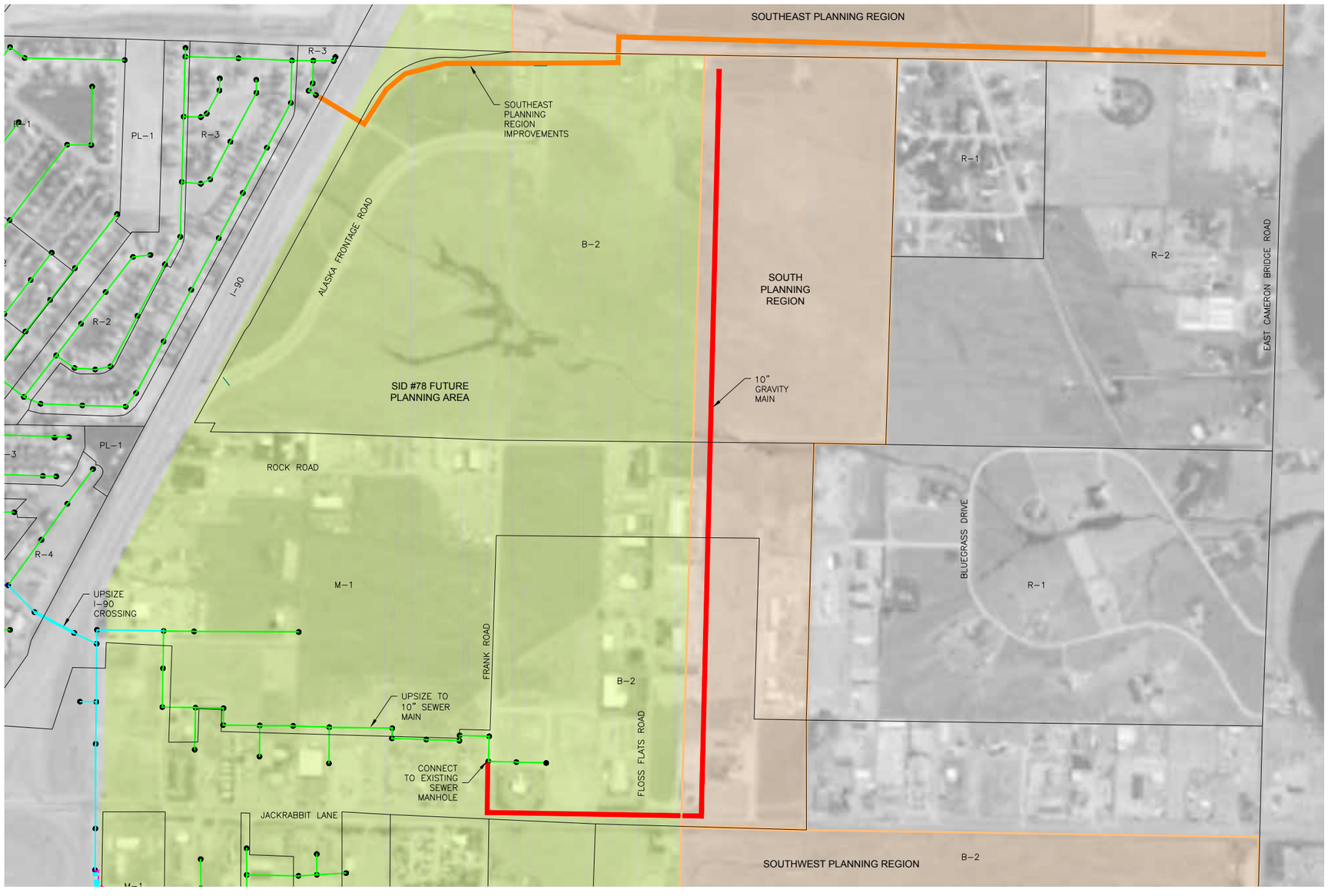

0 400' 800' 1200'
SCALE

ZONING INDEX

ZONE	DESCRIPTION
AS	Agricultural Suburban District
BP	Business Park
BP-10	Business Park
B-2	Highway Business District
B-3	Central Business District
M-1	Commercial-Light Manufacturing District
M-2	Manufacturing and Industrial District
PL-1	Public Lands and Institutions
R-1	Residential Single Family
R-1-T	Residential Transitional District
R-2	Residential Single Family District Medium Density
R-2-D	Residential One and Two Family
R-2-M	Residential Single Family and Manufactured Homes
R-3	Residential Medium Density District
R-3-Multi	Residential Multi-Family District
R-4	Residential Apartment District
R-4-1	Residential Transitional District
RS-M	Residential Suburban Manufactured

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BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

SOUTH PLANNING REGION PROPOSED IMPROVEMENTS

FIG 6-5.DWG
FIGURE 6-5

6.1.6 Southwest Planning Region

The southwest planning region is located west and south of SID #78. The region includes 709 acres which are zoned for AS, R-1, R-2, and B-2. The design peak hour flow is estimated to be 2,138 gpm (3.08 MGD). The northwest corner of the southwest planning region is at a lower elevation than the existing SID #78 Lift Station; therefore, it is proposed to collect the entire planning region with a 24-inch gravity trunk main and discharge to a new lift station near the intersection of Amsterdam Road and Thorpe Road. Like the proposed Northwest Regional Lift Station, the design of the proposed Southwest Regional Lift Station should consider a triplex design. Reference previous Northwest Regional Lift Station discussions for further detail.

A new 12-inch force main would convey the flows to either the SID #78 Lift Station or the sewer manhole in Amsterdam Road where the SID #78 force main ends. Discharging to the existing manhole is expected to be the least expensive option. Depending on the development in the Southwest Planning Region, it may be possible to abandon the SID #78 Lift Station by conveying it to the Southwest Regional Lift Station through new gravity mains. If, instead, the new force main discharges to the SID #78 Lift Station, then significant improvements are expected. The SID #78 Lift Station was not designed for flows occurring outside the extents of the SID #78 planning area; therefore, the lift station and force main must be modified to accommodate the additional flows. The new peak hour flow at the SID #78 Lift Station would be:

590 gpm + 2,138 gpm = **2,728 gpm.**

The proposed peak hour flow is significantly higher than the projected peak hour flow in the SID #78 planning area; significant changes to the wet well and pumps will be necessary to accommodate the new design flow. A triplex lift station, similar to the proposed Northwest and Southwest Regional Lift Stations, is likely warranted; however, the existing wet well dimensions are unlikely to accommodate three larger pumps. The force main from the existing station must be upsized to 12-inch diameter to maintain velocities below 8 ft/sec under ultimate buildout conditions. All alternatives should be considered when development in the Southwest Planning Region begins to determine the most cost-effective alternative for the City.

Development in the southwest planning region will affect the SID #78 Lift Station, 6-inch force main, the I-90 crossing, the 21-inch trunk main, and the outfall sewer. Impacts to the interstate crossing and trunk mains are discussed in Section 6.2. Figure 6-6 presents the proposed improvements in the southwest planning region, including the new lift station.

ZONING INDEX

ZONE	DESCRIPTION
AS	Agricultural Suburban District
BP	Business Park
BP-10	Business Park
B-2	Highway Business District
B-3	Central Business District
M-1	Commercial-Light Manufacturing District
M-2	Manufacturing and Industrial District
PL-1	Public Lands and Institutions
R-1	Residential Single Family
R-1-T	Residential Transitional District
R-2	Residential Single Family District Medium Density
R-2-D	Residential One and Two Family
R-2-M	Residential Single Family and Manufactured Homes
R-3	Residential Medium Density District
R-3-Multi	Residential Multi-Family District
R-4	Residential Apartment District
R-4-1	Residential Transitional District
RS-M	Residential Suburban Manufactured

NOTE:
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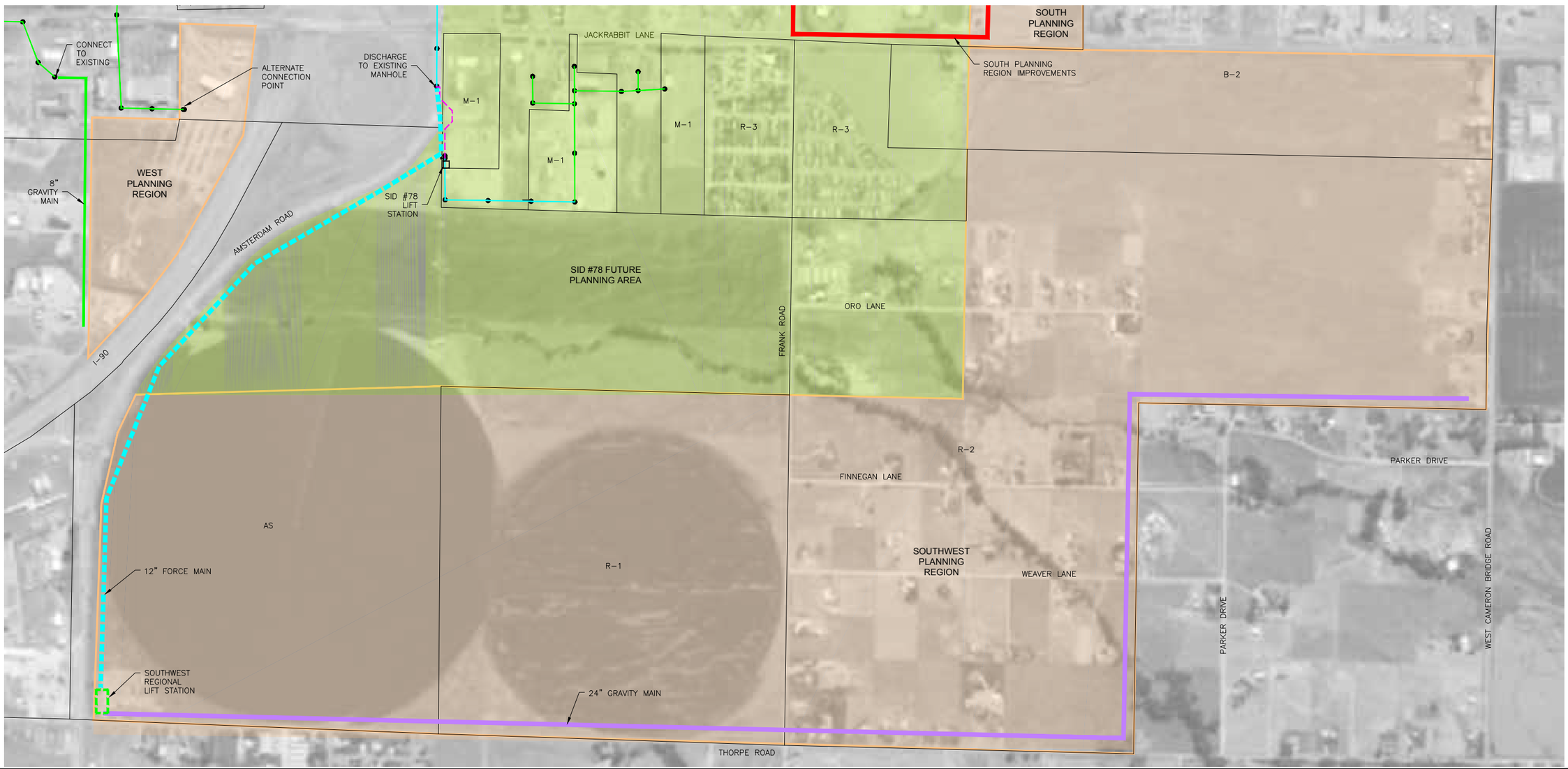
0 400' 800' 1200'
SCALE

LEGEND

PROPOSED	EXISTING	
		6" SANITARY SEWER
		8" SANITARY SEWER
		10" SANITARY SEWER
		12" SANITARY SEWER
		15" SANITARY SEWER
		18" SANITARY SEWER
		21" SANITARY SEWER
		24" AND LARGER SANITARY SEWER
		SANITARY SEWER – SIZE UNKNOWN
		4" FORCEMAIN
		6" FORCEMAIN
		8" FORCEMAIN
		10" FORCEMAIN
		12" FORCEMAIN
		ZONING BOUNDARY
		SEWER MANHOLE (NOT ALL SHOWN.)
		LIFT STATION
		PLANNING REGION
		SID #78 FUTURE PLANNING AREA



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WEST AND SOUTHWEST PLANNING REGIONS PROPOSED IMPROVEMENTS

FIG 6-6.DWG
FIGURE 6-6

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 6-6.dwg, 3/9/2018 4:26:01 PM, CEJ

6.1.7 West Planning Region

The final planning region, the west region, is the smallest at just 37 acres. It is zoned for M-2 and B-2, resulting in a peak hour design flow of 99 gpm. The region appears to slope to the north with a potential point of connection into one of two existing sewer mains near West Madison Avenue. North of the street, an 8-inch sewer flows from the Town Pump to the Jackrabbit Lift Station. South of West Madison Avenue, an existing 8-inch sewer main near the Albertsons grocery store conveys flows to a 10-inch crossing under the railroad and Frontage Road. Given the small peak hour flow rate, an 8-inch gravity main is sufficient to convey the flows to either sewer. Figure 6-6 identifies the available connections for a new main in the west planning region.

The west planning region and estimated peak hour flow are relatively small, so impacts to the existing gravity mains are not expected to be significant; however, as development occurs, flow monitoring is recommended at key infrastructure such as the Jackrabbit Lift Station and the 10-inch crossing under the Frontage Road.

6.2 DOWNSTREAM IMPACTS OF FUTURE DEVELOPMENT

The downstream impacts of development in the planning regions were briefly discussed in Section 6.1; however, only localized impacts were addressed. This section will evaluate the impacts to key crossings, lift stations, and trunk mains caused by full development in the planning regions. Unless otherwise noted, recommended improvements should not be initiated until they are needed.

Impacts to existing infrastructure will be analyzed based on flow estimates referencing the City's zoning mapping and associated unit flow criteria. Flow rates calculated based on this methodology are expected to be conservative, especially for existing development, and essentially represent ultimate buildout. It is impractical to accurately predict the rate of development or buildout date for any developed area. As a result, scheduling infrastructure needs to serve future development provides no beneficial value.

Although wastewater design flows in developed and undeveloped basins are estimated in accordance with current City zoning, acreage, and per capita daily design criteria, the outfall sewer capacity will be evaluated relative to the 20-year design flow presented in Chapter 5: **5.511 MGD** or **3,827 gpm**. Differentiating localized design standards from comprehensive collection system conditions accounts for attenuation of sewage flow through the miles of piping and eliminates the overconservative nature of applying criteria meant for individual developments. More simplistically, this approach essentially considers the trunk main an extension of the Belgrade Wastewater Treatment Plant.

6.2.1 Ryen Glenn Lift Station and Force Main

The peak hour design capacity of the Ryen Glenn Lift Station was intended to accommodate full development of both the Ryen Glenn Estates and Meadowlark Ranch subdivisions, or a peak hour flow of 520 gpm. The estimated peak hour flows in the northeast and east planning regions are 308 gpm, 456 gpm, and 402 gpm. The estimated future peak hour flow contributing to the Ryen Glenn Lift Station is calculated in Table 6-2.

Table 6-2 Ryen Glenn Lift Station Design Flow	
Location	**Peak Hour Flow**
Ryen Glenn Estates & Meadowlark Ranch	520 gpm (0.75 MGD)
Northeast Planning Region	308 gpm (0.44 MGD)
East 1 Planning Region	456 gpm (0.66 MGD)
East 2 Planning Region	402 gpm (0.58 MGD)
Total	***1,686 gpm (2.43 MGD)***

The future peak hour flow rate is more than triple the existing pumping capacity of 520 gpm. As development in the planning regions occurs, the Ryen Glenn Lift Station will be insufficient. The station should be re-evaluated and upsized as contributing flows near the current station capacity. Larger flows will require larger pumps, motors, and increased emergency power capacity.

Under the future peak hour flow, the velocity in the existing 8-inch force main would be 10.8 ft/sec. Montana DEQ allows a maximum velocity of only 8 ft/sec and the EPA recommends that the velocity not exceed 10 ft/sec; therefore, it is recommended to upsize the force main to at least 10 inches. The velocity in a 10-inch force main with 1,686 gpm is 6.9 ft/sec.

6.2.2 Existing Interstate 90 Crossing

As discussed in Chapter 3, the capacity of the existing I-90 crossing is 1,850 gpm at 75%-full flow and 2,030 gpm at full pipe flow. According to design drawings, the existing dual 12-inch pipes slope at 0.444%. Two planning regions are proposed to contribute flow to the crossing: south and southwest. The crossing currently serves SID #78 and the future planning area surrounding the SID. The estimated peak hour flow which could contribute to the crossing includes full development of the SID #78 planning area, the south planning region, and the southwest planning region. Table 6-3 summarizes the peak hour demands contributing to the crossing.

Table 6-3 Existing Interstate 90 Crossing Design Flow	
Location	**Peak Hour Flow**
SID #78 Future Planning Area	590 gpm
South Planning Region	445 gpm
Southwest Planning Region	2,138 gpm
Total	***3,173 gpm***

The capacity of the existing crossing is not sufficient for full development of the planning regions and SID #78. To meet the City's design policy, a single 21-inch pipe, sloping at 0.444%, would be necessary to convey the peak hour flow. Depending on the site conditions, it may be necessary to upsize the existing 12-inch pipes or to add a third pipe. If significant development is proposed in the planning regions, it is recommended to monitor the flow conveyed by the existing crossing and to evaluate whether sufficient cover and space exist to upsize the existing crossing.

6.2.3 East Interceptor

As discussed in Chapter 3, the theoretical maximum capacity of the 21-inch diameter east interceptor is 2,419 gpm or 2,050 gpm at 75%-full flow. Development in the southeast, south, and southwest planning regions will all contribute new wastewater flows to the east interceptor. The existing flow contributing to the east interceptor was conservatively estimated by examining the zoning in the area north of I-90. The contributing area is approximately 203 acres with a peak hour flow of 925 gpm. Calculations are provided in Appendix 6. The total flow contributing to the interceptor is calculated in Table 6-4.

Table 6-4
East Interceptor Design Flow

Location	Peak Hour Flow
Existing Service Area North of Interstate 90	925 gpm
SID #78 Future Planning Area	590 gpm
Southeast Planning Region	750 gpm
South Planning Region	445 gpm
Southwest Planning Region	2,138 gpm
Total	***4,848 gpm (7.0 MGD)***

The peak flow which will contribute to the interceptor is significant. As previously discussed, the peak hour flows estimated from the City's zoning methodology are conservative and result in higher flows than the population analysis documented in Chapter 5. The peak hour demand presented in Table 6-4 is approximately 1.5 MGD **higher** than the projected 20-year design peak hour flow for the outfall pipe and wastewater treatment plant. The capacity of the existing 21-inch interceptor, at full flow, is clearly inadequate for the conservative peak hour flow of 7.0 MGD. If a new pipe were installed parallel to the existing interceptor, assuming both pipes were flowing no more than 75% full and at minimum slopes, a 27-inch diameter main would be required.

Given the conservative nature of the estimated peak hour flow contributing to the east interceptor, it is recommended to implement flow monitoring as development is proposed in the interceptor's contributing area. Establishing a baseline flow for existing development will provide more accurate data toward assessing the existing gravity main and scheduling improvements.

6.2.4 Outfall Sewer

The existing 21-inch outfall sewer is a critical component in the gravity collection system. As discussed in Chapter 3, the full flow capacity of the outfall sewer is **3.24 MGD (2,250 gpm)**. It will convey all wastewater flows from the City except those originating east of the Belgrade Wastewater Treatment Plant: Ryen Glenn Estates subdivision, Meadowlark Ranch subdivision, northeast planning region, and east planning regions. The projected design peak hour flow, presented in Chapter 5, is 5.511 MGD, and includes the entire City of Belgrade. Table 6-2 presented the peak hour flow rates that will not contribute to the outfall sewer: **1,686 gpm (2.43 MGD)**. Therefore, the estimated peak hour flow which will be conveyed by the outfall sewer is equal to:

5.511 MGD – 2.43 MGD = **3.08 MGD**

The estimated peak hour design flow of the outfall sewer is 3.08 MGD, or slightly below the full flow capacity of the 21-inch piping. While the analysis indicates the sewer should not reach full capacity during the planning period, it is recommended to monitor the sewer flows over time.

The flow meter, currently located in the weir box, reports flows from both the outfall sewer and Ryen Glenn Lift Station. When the influent meter indicates the peak hour flow to the wastewater treatment plant is equal to the capacity of the outfall sewer and the pump capacity at Ryen Glenn, the outfall sewer should be reassessed. According to the nominal pump capacity at Ryen Glenn, the target flow rate is:

0.75 MGD + 3.24 MGD = **3.99 MGD**

6.3 EXISTING DEFICIENCIES

Several deficiencies were identified within the collection system and lift stations in Chapter 3. Recommended improvements ranged from minor repairs to major replacement. The following sections will summarize the recommended improvements and any available alternatives.

Planning level construction cost estimates were prepared for the lift station improvements in 2017. Costs have been adjusted for inflation with the Engineering News-Record (ENR) 20-City Construction Cost Index. The average inflation rate during the past five years, according to the ENR, is 3.0%.

6.3.1 Collection System

The physical condition of the collection system is generally good; City personnel did not report any major issues except at the RV dump stations. In the past, the City has been required to repair pumps and equipment at the Jackrabbit Lift Station after a flexible drain hose entered the sewer system. It is recommended that the City consider the solutions presented in Chapter 3 and implement City standards for future RV dump stations to minimize the chance of hoses or debris entering the City sewer system.

Various deficiencies reported in the 1998 *Wastewater Treatment and Collection Facilities Plan* have not been addressed including replacement of clay tile pipe and disconnecting a storm drain inlet which discharges to the sewer system. The 1998 report indicates the clay tile pipe is in the vicinity of North Quaw Boulevard, North Kennedy Street, West Central Avenue, and West Main Street. It is recommended that the clay tile pipe, if it remains, be replaced. In addition, the storm drain inlet which is reportedly connected to the sewer system, location unknown, should be disconnected. No increases to the City's operation and maintenance (O&M) costs are anticipated from the proposed improvements.

6.3.2 Lift Station #1: Jackrabbit

The Jackrabbit Lift Station is nearly at capacity, yet appears to be in relatively good working condition. The recommended improvements include cleaning the valve vault floor drain, modify the level alarms to comply with Circular DEQ-2 requirements, enable flow measurement and reporting capabilities, install transducer protection from turbulent inflow conditions and replace the level transducer. The recommendations are considered maintenance and could be completed by City staff; however, a construction cost estimate has been prepared for the work to provide a conservative budget. Table 6-5 presents the proposed construction budget assuming a bid date of 2018.

Table 6-5 Jackrabbit Lift Station Construction Cost Estimate				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Mobilization	5	%	---	$ 2,100.00
Bypass Pumping	1	LS	$ 25,000.00	$ 25,000.00
Clean Wet Well	1	LS	$ 1,000.00	$ 1,000.00
Remove and Replace Level Measurement System	1	LS	$ 2,500.00	$ 2,500.00
Perforated 8" PVC Pipe Stilling Basin	1	LS	$ 1,000.00	$ 1,000.00
Stainless Steel Stilling Basin Supports	1	LS	$ 1,500.00	$ 1,500.00
Flush Valve Vault Floor Drain	1	LS	$ 500.00	$ 500.00
Pump Control Modifications	1	LS	$ 5,000.00	$ 5,000.00
Miscellaneous Fieldwork or Materials	5,000	Units	$ 1.00	$ 5,000.00
			Subtotal	**$ 43,600.00**
			Contingency 15%	$ 6,540.00
			Total Construction Estimate	**$ 50,140.00**
			Administrative, Engineering and Legal 25%	$ 12,535.00
			Total	**$ 62,675.00**
			Inflation (1 year) 3.0%	$ 1,880.25
			Estimated Future Cost (rounded)	**$ 65,000.00**

Replacing the pressure transducer and installing a stilling basin will require bypass pumping. Several gravity mains discharge into the wet well, therefore bypass piping will be a significant expense and effort. The proposed improvements are not expected to increase City O&M costs. The budgetary 2018 construction cost is $65,000.

6.3.3 Lift Station #2: Cruiser

The condition of the Cruiser Lift Station has deteriorated in the past few years. Major issues include excessive pump run times, aging equipment, and lack of a backup power supply. The peak hour flow to the station also currently exceeds the pumping capacity. Repair or replacement of the lift station was recommended in Chapter 3. As mentioned in Section 6.1, work at the Cruiser Lift Station will be affected by improvements in the northwest planning region. Several alternatives are available to remediate the Cruiser Lift Station: Alternative LS2-1: Repair Lift Station and Discharge to Existing Force Main, Alternative LS2-2: Repair Lift Station and Discharge to Northwest Regional Lift Station, and Alternative LS2-3: Abandon Lift Station and Reconstruct Gravity Mains to Northwest Regional Lift Station. Each alternative is evaluated below.

6.3.3.1 Alternative LS2-1: Repair Lift Station and Discharge to Existing Force Main

Alternative LS2-1 would allow the City to implement repairs and improvements at the Cruiser Lift Station more quickly than either of the other alternatives. The work would not be dependent on the construction of the Northwest Regional Lift Station; therefore, the pump and wet well design would be based on discharging to the existing 10-inch force main in Dry Creek Road. Increased pumping capacity is recommended to accommodate the peak hour flow calculated in Chapter 3. All aspects of the lift station would be modified to meet current Circular DEQ-2 standards including installing an emergency generator. The existing site may not be sufficient to construct a generator building. As a result, the station footprint and associated security fencing should be increased within City right-of-way. Table 6-6 presents a budgetary construction cost estimate to repair the Cruiser Lift Station.

While Alternative LS2-1 would allow the City to implement repairs to the Cruiser Lift Station independent of development in the northwest planning region, the alternative is not compatible with the proposed Northwest Regional Lift Station. The Northwest Regional Lift Station is proposed to connect to the 10-inch force main in Cruiser Lane and Dry Creek Road. At that time, the hydraulic conditions at the Cruiser Lift Station are expected to change. The adjustment may be sufficient to affect the operation of the pumps and motors, requiring different equipment and additional capital costs to adapt the lift station to the new hydraulic conditions.

Table 6-6 Cruiser Lift Station - Alternative LS2-1 Construction Cost Estimate				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Mobilization	5	%	---	$ 21,000.00
Temporary Bypass Pumping	1	LS	$ 75,000.00	$ 75,000.00
Demo Piping and Appurtenances in Wet Well	1	LS	$ 2,500.00	$ 2,500.00
Clean and Refurbish Concrete Wet Well	1	LS	$ 20,000.00	$ 20,000.00
Install Valve Vault Drain	1	LS	$ 5,500.00	$ 5,500.00
Two Submersible Pumps, Motors, and Accessories	1	LS	$ 75,000.00	$ 75,000.00
6" Ductile Iron Pipe and Fittings	50	LF	$ 160.00	$ 8,000.00
Miscellaneous Pipe Supports	1	LS	$ 4,500.00	$ 4,500.00
Remove and Replace Level Measurement System	1	LS	$ 2,500.00	$ 2,500.00
Perforated 8" PVC Stilling Basin	1	LS	$ 1,000.00	$ 1,000.00
Stainless Steel Stilling Basin Supports	1	LS	$ 1,500.00	$ 1,500.00
Lift Station Site Grading and Restoration	1	LS	$ 4,000.00	$ 4,000.00
Bollard	6	EA	$ 700.00	$ 4,200.00
Chain Link Fence with Barbed Wire and Gate	160	LF	$ 25.00	$ 4,000.00
Gravel Access Road and Parking	135	SY	$ 30.00	$ 4,050.00
Geotextile Separation Fabric	135	SY	$ 2.00	$ 270.00
Backup Generator and ATS	1	EA	$ 80,000.00	$ 80,000.00
Electrical Modifications and Upgrades	1	LS	$ 40,000.00	$ 40,000.00
Concrete Housekeeping Pad	1	LS	$ 1,500.00	$ 1,500.00
Remove and Replace Controls and Communication	1	LS	$ 35,000.00	$ 35,000.00
Miscellaneous Fieldwork or Materials	40,000	Units	$ 1.00	$ 40,000.00
			Subtotal	**$ 429,520.00**
			Contingency 15%	$ 64,428.00
			Total Construction Estimate	**$ 493,948.00**
			Administrative, Engineering and Legal 25%	$ 123,487.00
			Total (rounded)	**$ 618,000.00**
			Inflation (1 year) 3.0%	$ 18,540.00
			Estimated Future Cost (rounded)	**$ 640,000.00**

The 2018 construction cost is estimated to be $640,000. The proposed changes are not expected to significantly increase City O&M efforts. Some additional tasks associated with maintaining the emergency generator will be required; however, the City's current efforts to repeatedly repair the Cruiser Lift Station would be eliminated.

6.3.3.2 Alternative LS2-2: Repair Lift Station and Discharge to Northwest Regional Lift Station

Alternative LS2-2 proposes to implement repairs at the Cruiser Lift Station in conjunction with construction of the Northwest Regional Lift Station. The alternative would address the deficiencies at the lift station; however, the work would necessitate redesigning the pumps and wet well levels to accommodate new hydraulic conditions. A new force main would convey flows from the lift station to a manhole north of Cruiser Lane, in Jackrabbit Lane. New gravity mains in Jackrabbit Lane would then carry flows north to the proposed Northwest Regional Lift Station.

Construction costs for Alternative LS2-2 cannot be accurately presented without accounting for costs associated with the proposed Northwest Regional Lift Station, new gravity main, and new force main. In addition, the total cost would not be the sole responsibility of the City of Belgrade. Costs would be shared amongst the City and the developers whose projects will contribute wastewater to the proposed Northwest Regional Lift Station.

6.3.3.3 Alternative LS2-3: Abandon Lift Station and Reconstruct Gravity Mains to Northwest Regional Lift Station

Alternative LS2-3 proposes to abandon the Cruiser Lift Station and redesign the existing gravity sewer mains near the intersection of Cruiser Lane and Jackrabbit Lane. As discussed in Section 6.1, the existing sewer mains and manholes near the lift station are quite deep and it may not be feasible to simply design and construct a new gravity main from Cruiser Lane to the proposed Northwest Regional Lift Station. Based on limited topographical data, it appears the wet well at the Northwest Regional Lift Station would need to be extremely deep and in turn prohibitively expensive to build and operate. In order to abandon the Cruiser Lift Station, the existing gravity mains must be replaced at a shallower depth. Several blocks of reconstruction or replacement may be necessary as it is not apparent whether the sewer mains are deep throughout the Cruiser Lift Station service area.

Given the unknowns associated with Alternative LS2-3, it is recommended that the City eliminate it from further consideration; however, if the City strongly prefers to attempt to remove the Cruiser Lift Station from service, then it is recommended that a field investigation be scheduled. Topographic surveying and manhole depth measurements should be collected at sewer manholes surrounding and feeding the wet well to assess the extents of any reconstruction efforts. Limited surveying of the proposed Northwest Regional List Station site is also recommended to confirm elevations relative to the existing gravity main system.

6.3.4 Lift Station #3: Gallatin Farmers

The Gallatin Farmers Lift Station only serves one block of commercial properties; however, its condition and functionality have decreased significantly in recent years. The station experiences significant pump run times, is reaching the end of its useful life, and has no backup power supply. The check valves have failed in the past and there may be an issue with industrial dyes and trash entering the station. In addition, the capacity of one pump is significantly less than the other.

Prior to any significant efforts at the lift station, it is recommended the City contact local business owners and request they do not dump trash or debris into sewer lines or drains. It is also recommended to investigate the source and effects of the dye which has been observed in the wet well, valve vault, and equipment. If the dye if found to detrimentally affect mechanical equipment and instrumentation or biological activity in the wastewater treatment facility, pretreatment at the source may be necessary.

The recommended improvements include either repairing or replacing the station. Replacing the station would be appropriate if the physical condition of the wet well and valve vault are beyond repair. Chapter 3 concluded the concrete structures are in good condition; therefore, it is recommended to repair the Farmers Lift Station rather than replace it. The project should include replacing all mechanical and electrical components including submersible pumps, motors, valves, piping, and controls. A backup power supply will be required; the station appears to be located within City right-of-way, so the generator will probably have to be housed in a weather proof enclosure rather than in a building. The capacity of the station is not expected to increase dramatically; however, the capacity of the pumps should be evaluated during design. The wet well and valve vault should be cleaned, inspected, and repaired or coated, if necessary. Table 6-7 presents a budgetary construction cost estimate to repair the Gallatin Farmers Lift Station.

Table 6-7 Gallatin Farmers Lift Station Construction Cost Estimate				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Mobilization	5	%	---	$ 17,000.00
Temporary Bypass Pumping	1	LS	$ 50,000.00	$ 50,000.00
Demo Piping and Appurtenances in Wet Well	1	LS	$ 2,500.00	$ 2,500.00
Clean and Refurbish Concrete Wet Well	1	LS	$ 20,000.00	$ 20,000.00
Clean Concrete Valve Vault and Drain	1	LS	$ 10,000.00	$ 10,000.00
Two Submersible Pumps, Motors, and Accessories	1	LS	$ 50,000.00	$ 50,000.00
4" Ductile Iron Pipe and Fittings	50	LF	$ 140.00	$ 7,000.00
Miscellaneous Pipe Supports	1	LS	$ 4,000.00	$ 4,000.00
Remove and Replace Level Measurement System	1	LS	$ 2,500.00	$ 2,500.00
Perforated 8" PVC Stilling Basin	1	LS	$ 1,000.00	$ 1,000.00
Stainless Steel Stilling Basin Supports	1	LS	$ 1,500.00	$ 1,500.00
Lift Station Site Grading and Restoration	1	LS	$ 2,500.00	$ 2,500.00
Bollard	6	EA	$ 700.00	$ 4,200.00
Gravel Access Road and Parking	90	SY	$ 30.00	$ 2,700.00
Geotextile Separation Fabric	90	SY	$ 2.00	$ 180.00
Backup Generator and ATS	1	EA	$ 60,000.00	$ 60,000.00
Electrical Modifications and Upgrades	1	LS	$ 40,000.00	$ 40,000.00
Concrete Housekeeping Pad	1	LS	$ 1,500.00	$ 1,500.00
Remove and Replace Controls and Communication	1	LS	$ 35,000.00	$ 35,000.00
Miscellaneous Fieldwork or Materials	30,000	Units	$ 1.00	$ 30,000.00
			Subtotal	**$ 341,580.00**
		Contingency	15%	$ 51,237.00
			Total Construction Estimate	**$ 392,817.00**
		Administrative, Engineering and Legal	25%	$ 98,204.25
			Total (rounded)	**$ 492,000.00**
		Inflation (1 year)	3.0%	$ 14,760.00
			Estimated Future Cost (rounded)	**$ 510,000.00**

The budgetary 2018 construction cost is $510,000. The repair project is not expected to increase O&M costs.

6.3.5 Lift Station #4: SID #78/Truck Stop

The SID #78 Lift Station has been in operation since 2009 and is generally in good condition. As discussed in Chapter 3, the station has a history of probe errors and questionable pumping frequency. It also does not have a bypass pumping connection. It is recommended to investigate the probe errors by inspecting, cleaning, and calibrating the probe. If the probe is found to be defective, then it should be replaced and a stilling basin installed. Once the probe is repaired or replaced, then the capacity of the pumps should be reassessed to ensure they are operating as designed. Table 6-8 presents a budgetary construction cost to replace the probe, install a stilling basin, and plumb a bypass pumping connection.

Table 6-8
SID #78 Lift Station
Construction Cost Estimate

Description	Quantity	Unit	Unit Cost	Total Cost
Mobilization	5	%	---	$ 2,100.00
Bypass Pumping	1	LS	$ 15,000.00	$ 15,000.00
Clean Wet Well	1	LS	$ 1,000.00	$ 1,000.00
Install Bypass Pumping Connection in Valve Vault	1	LS	$ 10,000.00	$ 10,000.00
Remove and Replace Level Measurement System	1	LS	$ 2,500.00	$ 2,500.00
Perforated 8" PVC Pipe Stilling Basin	1	LS	$ 1,000.00	$ 1,000.00
Stainless Steel Stilling Basin Supports	1	LS	$ 1,500.00	$ 1,500.00
Clean Valve Vault Floor Drain	1	LS	$ 500.00	$ 500.00
Pump Control Modifications	1	LS	$ 5,000.00	$ 5,000.00
Miscellaneous Fieldwork or Materials	5,000	Units	$ 1.00	$ 5,000.00
			Subtotal	**$ 43,600.00**
			Contingency 15%	$ 6,540.00
			Total Construction Estimate	**$ 50,140.00**
			Administrative, Engineering and Legal 25%	$ 12,535.00
			Total	**$ 62,675.00**
			Inflation (1 year) 3.0%	$ 1,880.25
			Estimated Future Cost (rounded)	**$ 65,000.00**

The budgetary 2018 construction cost is $65,000. No change in City O&M costs is expected.

6.3.6 Lift Station #5: Meadowlark/Powers

There have been no operational issues reported at the Meadowlark Lift Station. A few deficiencies were revealed in the evaluation documented in Chapter 3 including no emergency bypass pumping connection and a low-level alarm not reporting to the SCADA system. The capacity of the station also appears to be adequate.

It is recommended that a bypass pumping connection be installed and that the low-level alarm be activated in the pump controller, if available. In addition, the investigation revealed flow measurement capabilities exist in the control panel. It recommended to enable that function and

report the flows to the SCADA system. These tasks could be completed as City maintenance activities; however, a budgetary construction cost has been prepared for planning purposes. Table 6-9 presents the budgetary cost.

Table 6-9
Meadowlark Lift Station
Construction Cost Estimate

Description	Quantity	Unit	Unit Cost	Total Cost
Mobilization	5	%	---	$ 1,600.00
Bypass Pumping	1	LS	$ 10,000.00	$ 10,000.00
Clean Wet Well	1	LS	$ 1,000.00	$ 1,000.00
Install Bypass Pumping Connection in Valve Vault	1	LS	$ 10,000.00	$ 10,000.00
Clean Valve Vault Floor Drain	1	LS	$ 500.00	$ 500.00
Pump Control Modifications	1	LS	$ 5,000.00	$ 5,000.00
Miscellaneous Fieldwork or Materials	5,000	Units	$ 1.00	$ 5,000.00
			Subtotal	**$ 33,100.00**
		Contingency	15%	$ 4,965.00
			Total Construction Estimate	**$ 38,065.00**
		Administrative, Engineering and Legal	25%	$ 9,516.25
			Total	**$ 47,581.25**
		Inflation (1 year)	3.0%	$ 1,427.44
			Estimated Future Cost (rounded)	**$ 50,000.00**

The budgetary 2018 construction cost is $50,000. No change in City O&M costs is expected.

6.3.7 Lift Station #6: Ryen Glenn/Penwell Bridge

The Ryen Glenn Lift Station is less than ten years old and has not experienced any significant operational deficiencies. The assessment in Chapter 3 recommended the following: install a bypass pumping connection, enable station event log reporting to the SCADA system, and complete a draw down test to provide an updated pumping rate in the SCADA records. These tasks are considered maintenance; however, a budgetary construction cost has been prepared for planning purposes. Table 6-10 presents the cost estimate.

Table 6-10 Ryen Glenn Lift Station Construction Cost Estimate				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Mobilization	5	%	---	$ 2,100.00
Bypass Pumping	1	LS	$ 20,000.00	$ 20,000.00
Clean Wet Well	1	LS	$ 1,000.00	$ 1,000.00
Install Bypass Pumping Connection in Valve Vault	1	LS	$ 10,000.00	$ 10,000.00
Clean Valve Vault Floor Drain	1	LS	$ 500.00	$ 500.00
Pump Control Modifications	1	LS	$ 5,000.00	$ 5,000.00
Miscellaneous Fieldwork or Materials	5,000	Units	$ 1.00	$ 5,000.00
			Subtotal	**$ 43,600.00**
			Contingency 15%	$ 6,540.00
			Total Construction Estimate	**$ 50,140.00**
			Administrative, Engineering and Legal 25%	$ 12,535.00
			Total	**$ 62,675.00**
			Inflation (1 year) 3.0%	$ 1,880.25
			Estimated Future Cost (rounded)	**$ 65,000.00**

The budgetary 2018 construction cost is $65,000. No change in City O&M costs is expected.

7.0 TREATMENT AND DISPOSAL ALTERNATIVE EVALUATION

One of the objectives of this Master Plan is to develop and evaluate various treatment and disposal alternatives and select the most appropriate options for solving the issues facing the BWTP. It is crucial for the recommended improvements to provide a feasible method of meeting applicable design criteria and public health requirements over the design life of the project.

Alternatives considered are presented below. Treatment and disposal alternatives are considered in Sections 7.1 and 7.2, respectively. A description of each alternative and the rationale for inclusion as a viable option are discussed. Where an alternative is excluded from further consideration, justification for elimination is provided. Feasible alternatives are accompanied by general design description, site map and estimated capital and O&M costs.

7.1 Treatment Alternatives

Potential improvements to the City's existing treatment system are discussed in the sections to follow. An updated treatment system will be required to maintain compliance with state and federal discharge requirements as the City's population and raw wastewater flows increase with time.

7.1.1 Common Improvements

A headworks facility should be included in any treatment system upgrades, regardless of final recommendations. A new headworks should be included upstream of the primary treatment for each alternative presented in this Chapter. The purpose of a new facility is removal of large suspended solids and debris from the raw wastewater prior to primary treatment, ultimately improving the efficiency of the treatment system.

Because a headworks facility is included in each of the treatment system alternatives, a standalone construction cost estimate for the headworks facility has been prepared independent of any specific treatment alternative. Table 7-1 summarizes estimated construction costs. This cost estimate details anticipated construction expenses, including undeveloped design details equal to 10% of the construction subtotal, a 15% contingency, and anticipated engineering, administrative, and legal costs. The total estimated project cost for a new headworks facility is $2,662,500.

Table 7-1 Headworks Facility Construction Cost Estimate			
CONSTRUCTION COSTS			
General Conditions			
Bonding / Insurance / Project Mgmt & Admin / Mobilization			$111,500
Site Work			
Site Prep - Clearing and Grubbing		$1,600	
Excavation & Backfill		$11,000	
SUBTOTAL: SITE WORK			$12,600
Structural & Architectural			
Geotech & Foundation Systems		$58,000	
Building Cost		$315,000	
Channels & Grit Chamber		$70,800	
Bridge Cranes and Specialties		$100,000	
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$544,000
Process Equipment & Piping			
Screens	$115,000	$236,900	
Washer / Compactor	$50,000	$51,500	
Grit Equipment	$225,000	$231,800	
Instrumentation	$30,000	$30,900	
Influent Flow Sampler	$12,000	$12,400	
Process Gates, Piping, Flow Control, etc.	$57,500	$59,300	
Process Pumps	$10,000	$10,300	
SUBTOTAL: EQUIPMENT & FURNISHINGS			$633,100
Mechanical			
HVAC		$9,000	
PLUMBING		$5,300	
SUBTOTAL: MECHANICAL			$14,300
Electrical			
Electrical / Instrumentation & Controls			$388,500
SUBTOTAL			**$1,704,000**
Underdeveloped Design Details	10%		$170,400
Construction Contingencies	15%		$255,600
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$2,130,000**
NON-CONSTRUCTION COSTS			
SUBTOTAL: ADMINISTRATIVE, ENGINEERING AND LEGAL	25%		$532,500
TOTAL ESTIMATED PROJECT COST			**$2,662,500**

7.1.2 Alternative T-1: No Action

This alternative entails allowing the existing treatment system to remain operational without improvements. Based on previously described conversations with City personnel and site inspections, the current treatment plant is experiencing issues such as floating air lines, failing surface aerators and level transducers, and low accuracy inflow measurements. The BWTP is also nearing its design capacity. According to population projections and wastewater production rates previously discussed, the existing plant's average day design capacity of 903,000 gpd will be exceeded in the year 2023. Analysis performed in Chapter 4 also indicates the existing BWTP is currently at or exceeding its design loading capacity. Finally, to ensure maintained compliance with the City's existing TN loading limits, supplementary nutrient removal is required. For these reasons, Alternative T-1: No Action is not considered a feasible option for the City and will not be discussed further.

7.1.3 Alternative T-2: Total Retention Lagoons

Alternative T-2: Total Retention involves converting the existing aerated lagoons to total retention basins. Total retention lagoons are entirely evaporative systems, and as such, treated wastewater would not be discharged to the existing land application or IP beds. Because no wastewater is discharged from these systems, they are considered to have a number of environmental benefits. Additionally, the O&M tasks and utility costs would be minimal.

In order to facilitate sufficient evaporation, total retention lagoons must be shallow with large surface area. Due to the high projected average day flow rates for the City of Belgrade, the required pond size would be excessively large. The proximity of the lagoons to the Bozeman-Yellowstone International Airport limits the allowable water surface area, and as such, total retention is not considered feasible for the City of Belgrade.

7.1.4 Alternative T-3: Facultative Lagoons

Facultative lagoons are similar to aerated lagoons in that they rely on the naturally occurring bacteria to treat the impounded wastewater. Prior to the 2004 lagoon upgrades, the BWTP was a system of 4 facultative basins. Because air is not supplied to the lagoons to optimize mixing and oxygen transfer, the biological treatment happens much slower, requiring basin sizing to be much larger. As mentioned with Alternative T-2, the proximity to the Bozeman-Yellowstone International Airport limits the BWTP available water surface area. Therefore, Alternative T-3: Facultative Lagoons does not comply with design standards and is not a feasible option for the BWTP upgrades.

7.1.5 Alternative T-4: Existing Lagoon Upgrades

This alternative involves retaining existing system as is practical, in combination with upgrades to increase the capacity of the treatment system and allow the City to continue meeting allowable effluent limitation. Two sub-alternatives are considered within Alternative T-4, Alternative T-4A: Advanced Aeration with Tertiary Nutrient Removal and Alternative T-4B: Sequencing Batch Reactor with Facultative Biosolids Storage Lagoons. Each sub-alternative is detailed in the following sections. These sub-alternatives will allow the treatment plant to remain at the current location. Benefits to upgrading the existing system include, but are not limited to, reduced footprint of secondary treatment, minimal operational complexity, minimal solids handling costs, and available onsite emergency retention.

7.1.5.1 Alternative T-4A Advanced Aerated Lagoons with Tertiary Nutrient Removal

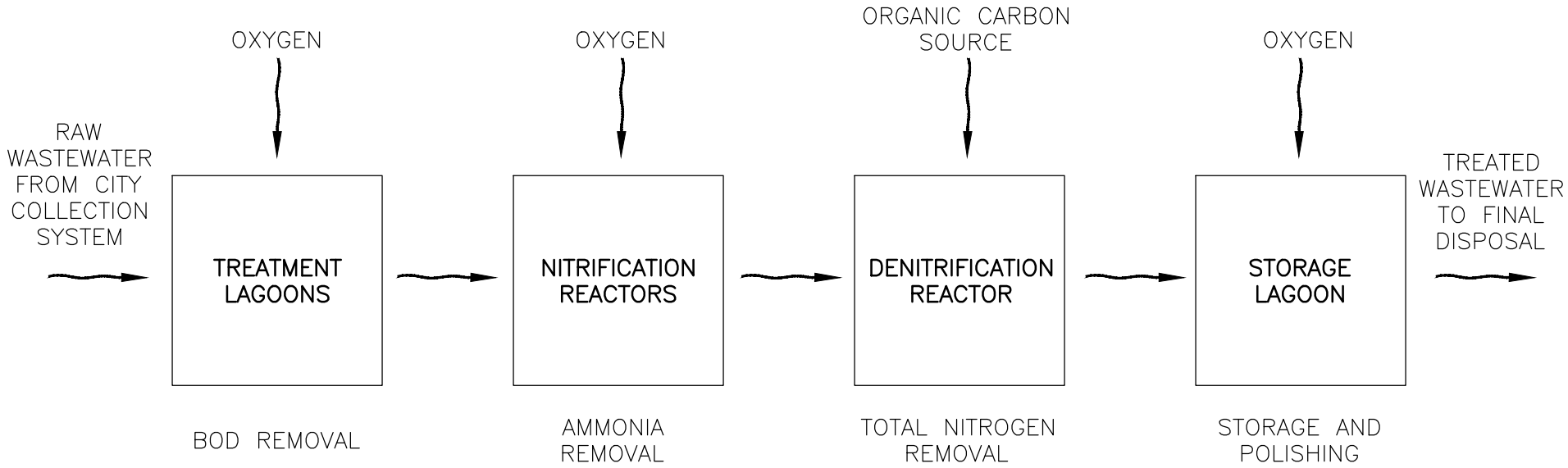
Alternative T-4A involves retrofitting the existing lagoons to include an advanced aeration system with tertiary nutrient removal. The improvements include replacing the existing aeration equipment with high efficiency fine bubble diffusers. The wastewater will be conveyed from the treatment basins to a series of nitrification and denitrification reactors. The treated wastewater will then be pumped to the storage lagoon for polishing and storage. A process flow diagram (PFD) is provided in Figure 7-1. Descriptions of each process are provided in the sections to follow.

Two proprietary processes were referenced for the conceptual planning of Alternative T-4A: LEMNA Environmental Technologies and Triplepoint Environmental. As a result, a number of options involving thermal regulation, denitrification and final storage are included in this alternative. The available options are described throughout the following sections; estimated capital improvement cost and annual O&M budgets were calculated with conservative assumptions. Should Alternative T-4A be selected for final design, consultation with City staff will be necessary to arrive at a detailed design most beneficial to the City of Belgrade. Proposals from LEMNA and Triplepoint, including preliminary design calculations and product literature, are included in Appendix 7.

7.1.5.1.1 Treatment Lagoons

The primary purpose of the treatment lagoons will be BOD removal. High efficiency fine bubble diffusers will replace the existing static tube aerators. These diffusers will optimize both mixing and oxygen transfer to maximize aerobic digestion while minimizing required energy consumption. Preliminary designs provided by both Triplepoint and LEMNA recommend tapered aeration. More aggressive oxygenation and mixing will occur within the first treatment basin, limiting with this system's available flow patterns. As such, the system will only operate in series; raw wastewater will flow from the new headworks facility to Lagoon #1, then on to Lagoon #2. The parallel flow configuration currently available to the City will no longer be an option.

Information provided by LEMNA and Triplepoint indicates between 6,000 scfm and 7,500 scfm of air flow at 5.6 psi to 6.2 psi discharge pressure will be required for the new system. Preliminary calculations estimate the air header pipe will need to be increased from an 18-inch diameter to a minimum size of 20-inches to maintain air velocities below 30 ft/sec. Preliminary calculations are provided in Appendix 7. Four new blowers, three for continuous operation and one for standby, are needed. The existing blowers occupy much of the available space in the existing pump house. Careful planning will be necessary during final design to ensure enough space is provided for the new blowers. Modifications to the existing pump house may result. Additionally, a real-time DO probe connected to a blower variable frequency drive (VFD) is recommended. This VFD will control blower run times based on DO concentrations; ultimately improving the energy efficiency of the system.



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BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MT

ALTERNATIVE T-4A: ADVANCED AERATION WITH TERTIARY NUTRIENT REMOVAL

PROCESS FLOW DIAGRAM

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DRAWN BY:	NMR
DESIGNED BY:	
QUALITY CHECK:	
DATE:	05-17-2017
JOB NO.	B16-048
CAD NO.	T-4 PFD

FIGURE

7-1

7.1.5.1.2 Nitrification Reactor

After initial BOD removal, the impounded wastewater will be conveyed to a series of nitrification reactors for ammonia removal. Nitrification converts ammonia to nitrates and nitrites in oxygen rich environments. The nitrification reactors consist of buried, flow-through concrete basins and include an aeration grid. Additional blowers will be connected to the aeration grid to supply the required oxygen for the reaction. Preliminary calculations, available in Appendix 7, indicate a minimum air header diameter of 10-inches is necessary to maintain acceptable air velocities. A separate blower house or an addition to the existing building will be required as space is limited within the current pump house. Plastic, porous media will be installed in each nitrification reactor to provide ample surface area for the nitrifying bacteria to form colonies. Additionally, the reactors will include an insulated cover to provide thermal regulation and optimize the nitrification process. Figure 7-2 illustrates the channelized, flow through nitrification reactor.

7.1.5.1.3 Denitrification Reactor

Following ammonia removal, wastewater will be conveyed to the denitrification reactor for final TN treatment. Denitrification occurs under anoxic conditions and converts nitrates and nitrites to diatomic nitrogen (N_2), a non-toxic substance. An external carbon source will be required to act as an electron acceptor for the reaction. An estimated 365 gpd of organic carbon will be required to feed the denitrification reaction. Based on installation of a 5,500-gallon storage tank, carbon materials must be delivered on a 15 day schedule. This storage tank may be housed in a new blower building. A common organic carbon source used by many municipalities is methanol due to its low cost and availability. Methanol is flammable, however, and would require additional capital cost for fire suppression systems and blast walls around the carbon storage. Other options, such as proprietary formulations like MicroC, produced by Environmental Operating Solutions, Inc. are non-flammable and would therefore not require the same level of safety precautions. These proprietary options are more expensive, however, and will cause increased O&M costs. Porous media will be necessary to provide sufficient surface area for the denitrifying heterotrophs to form colonies. A number of denitrification reactor configurations are available. An upflow sand filter or buried flow-through basin are potential choices.

Upflow sand filters are common for total nitrogen removal in municipal wastewater treatment. Wastewater is pumped to the top of the sand filter, where it enters the tank and flows down through the feed pipe. The water exits the feed pipe through a distributer and flows up though the filter bed where denitrification occurs. As the wastewater travels through the filter media, used sand travels downward to an air lift pipe. Compressed air will draw the sand upward while scouring it. The clean filter media is discharged from the air lift pipe at the top of the filter and returned to the filter bed. A small portion of the treated wastewater will wash over the filter media prior to the media's return to the filter bed. This water will rinse off any remaining impurities from the sand and be discharged from the filter through a weir. The treated wastewater will be discharged from the filter at the top of the tank. Preliminary calculations suggest a series of six upflow sand filters, each with an approximate footprint of 100 SF, will be required to

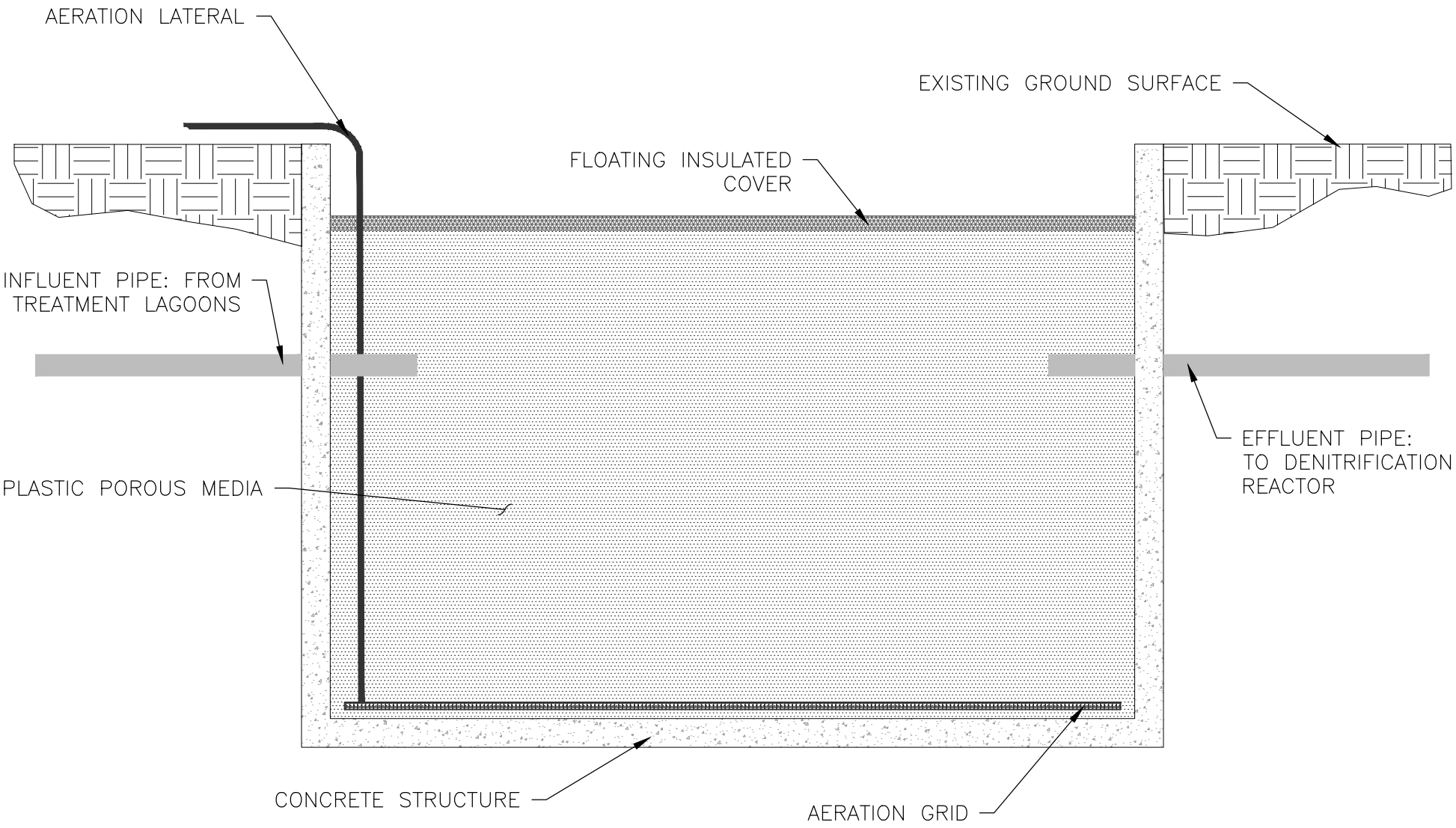
maintain effluent TN concentrations at or below 13.5 mg/l. Additionally, an enclosure around sand filters is recommended to provide thermal regulation, especially in the colder months. A schematic of an upflow sand filter, as shown in the EPA's Wastewater Management Fact Sheet, *Denitrifying Filters*, is provided in Figure 7-3.

Optionally, denitrification may also occur in a buried, channelized concrete basin. The basin would include an insulted cover to provide thermal regulation. Plastic porous media, similar to the media in the nitrification reactors, would be included to allow formation of denitrifying heterotrophic colonies. Preliminary design calculations suggest one 100,000-gallon denitrification basin would produce treated wastewater with TN concentration at or below 13.5 mg/l. This basin would be constructed in the same manner as the channelized, flow through nitrification reactor shown in Figure 7-2. The aeration grid along the bottom would be removed and a carbon source feed pipe would be included.

7.1.5.1.4 Storage Lagoon

Wastewater discharged from the denitrification reactor will comply with all design standards discussed in Chapter 5. The treated wastewater will be pumped to the storage lagoon until it can be discharged from the BWTP. Transfer pump details, O&M and capital costs are discussed later within this Alternative T-4.

The treated wastewater will be anoxic as it leaves the denitrification reactor; anoxic water is known to cause odor issues. To prevent odors within the storage lagoon, new high efficiency fine bubble diffusers will be installed, replacing the existing surface aerators. The new fine bubble diffusers will extend 2 feet vertically. Available storage will be discussed in greater detail in section 7.2 Disposal Alternatives. The far west portion of Lagoon #3 will not include aeration to provide a quiescent zone for any remaining solids to settle prior to final discharge.



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BELGRADE WASTEWATER MASTER PLAN
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ALTERNATIVE T-4A: ADVANCED AERATION WITH TERTIARY NUTRIENT REMOVAL

NITRIFICATION BASIN

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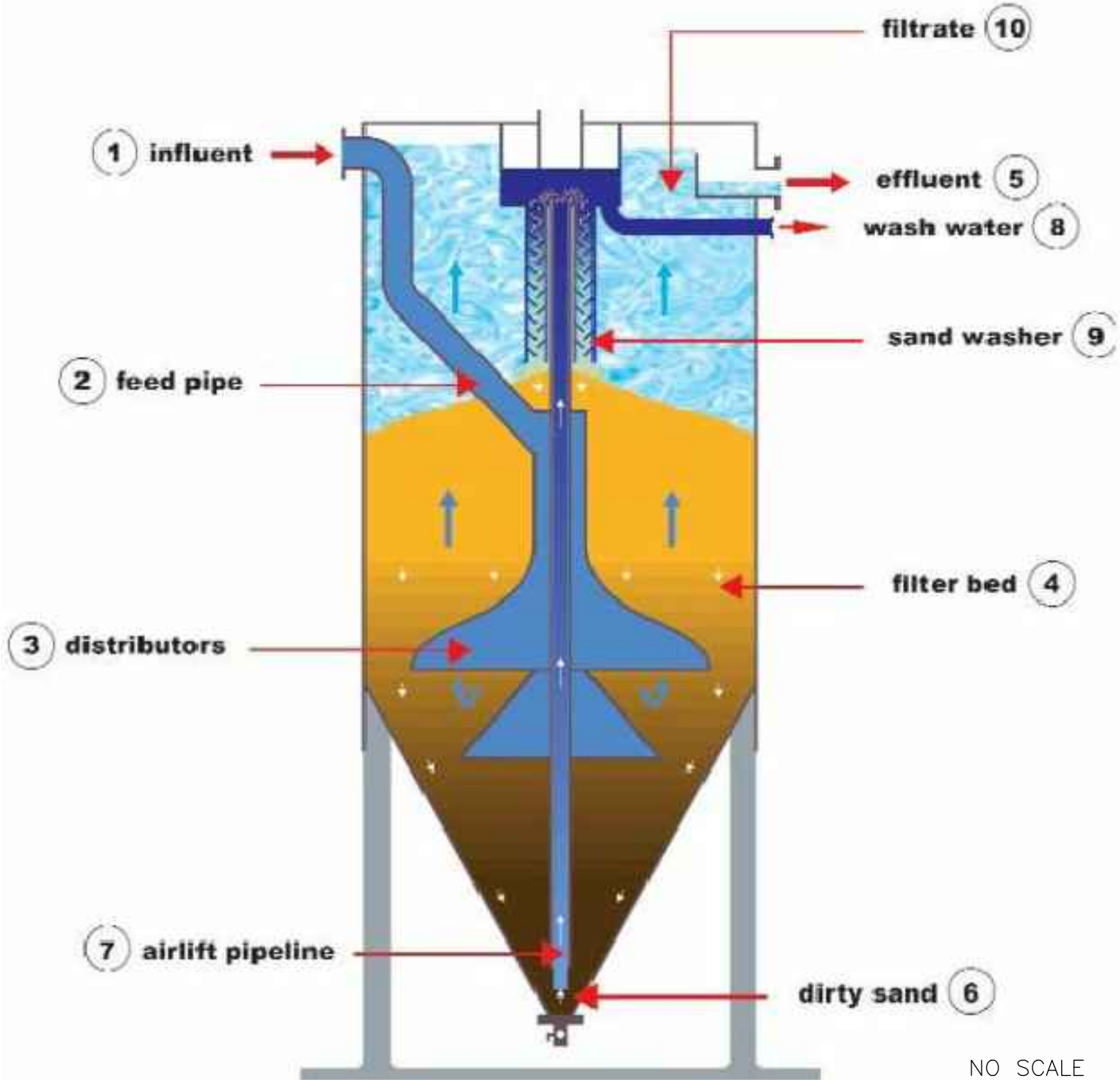
DRAWN BY:	NMR
DESIGNED BY:	
QUALITY CHECK:	
DATE:	05-17-2017
JOB NO.	B16-048
CAD NO.	T-4 NITRIFICATION BASIN

FIGURE

7-2



SOURCE: UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, WASTEWATER MANAGEMENT FACT SHEET: DENITRIFYING FILTERS. SEPTEMBER 2007.

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BELGRADE WASTEWATER MASTER PLAN **BELGRADE, MT**	TD&H Engineering tdhengineering.com	DRAWN BY: NMR DESIGNED BY: QUALITY CHECK: DATE: 5-17-2017 JOB NO. B16-048 CAD NO.T-4 UPFLOW SAND FILTER	FIGURE
ALTERNATIVE T-4: ADVANCED AERATION DENITRIFICATION REACTOR (UPFLOW SAND FILTER)			**7-3**

7.1.5.2 Map

The retrofitted treatment plant will be constructed within the footprint of the existing lagoons. Each proprietary system referenced for this alternative proposed a slightly different layout for overall treatment system. As a result, two possible treatment plant concept layouts are included. The layout for Alternative T-4A(1) involves retaining Lagoon #1 and #2 as the treatment lagoons. Wastewater will be conveyed to a series of three channelized nitrification reactors and single channelized concrete denitrification reactor. A heat exchanger is included upstream of the nitrification reactors to provide thermal regulation during colder months. Treated wastewater will be pumped to and stored in Lagoon #3 until final discharge. Alternative T-4A(1) is shown in Figure 7-4.

The second possible treatment plant layout is described as Alternative T-4A(2). In this option, Lagoon #1 will be the solitary treatment basin. A hydraulic baffle will be included in this option to divide Lagoon #1 into two treatment cells. An insulated cover, rated at R8 will be installed over Lagoon #1 for thermal regulation. Water will be conveyed to a channelized nitrification reactor, followed by six upflow sand filters operated in parallel, for denitrification. The upflow sand filters will be housed in a new building with the carbon source storage and nitrification blowers. Treated wastewater will then be pumped to Lagoons #2 and #3 for storage. Figure 7-5 illustrates Alternative T-4A(2).

It should be noted that the components of these two figures are not mutually exclusive. The treatment lagoon aeration system from one option can be used in conjunction with nitrification and denitrification system proposed in the other option. Final configuration will be defined during final design, should Alternative T-4A be selected.

LEGEND

- HIGH EFFICIENCY FINE BUBBLE DIFUSER
- NEW AIR HEADER
- AERATION LATERAL
- DISTRIBUTION PIPELINE
- TRANSFER LINE C–1
- TRANSFER LINE B–1
- TRANSFER LINE D–1
- BYPASS PIPELINE
- FLOW DIRECTION

NOTES:

1. SLUDGE SHALL BE REMOVED FROM ALL EXISTING LAGOONS.
2. EXISTING STATIC TUBE AND SURFACE AERATORS SHALL BE REMOVED.
3. EXISTING AIR HEADERS SHALL BE DEMOLISHED.

N

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SCALE

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DRAWN BY:	CJS
DESIGNED BY:	NMR
QUALITY CHECK:	
DATE:	04/05/2017
JOB NO.	B16-048
FIELDBOOK	

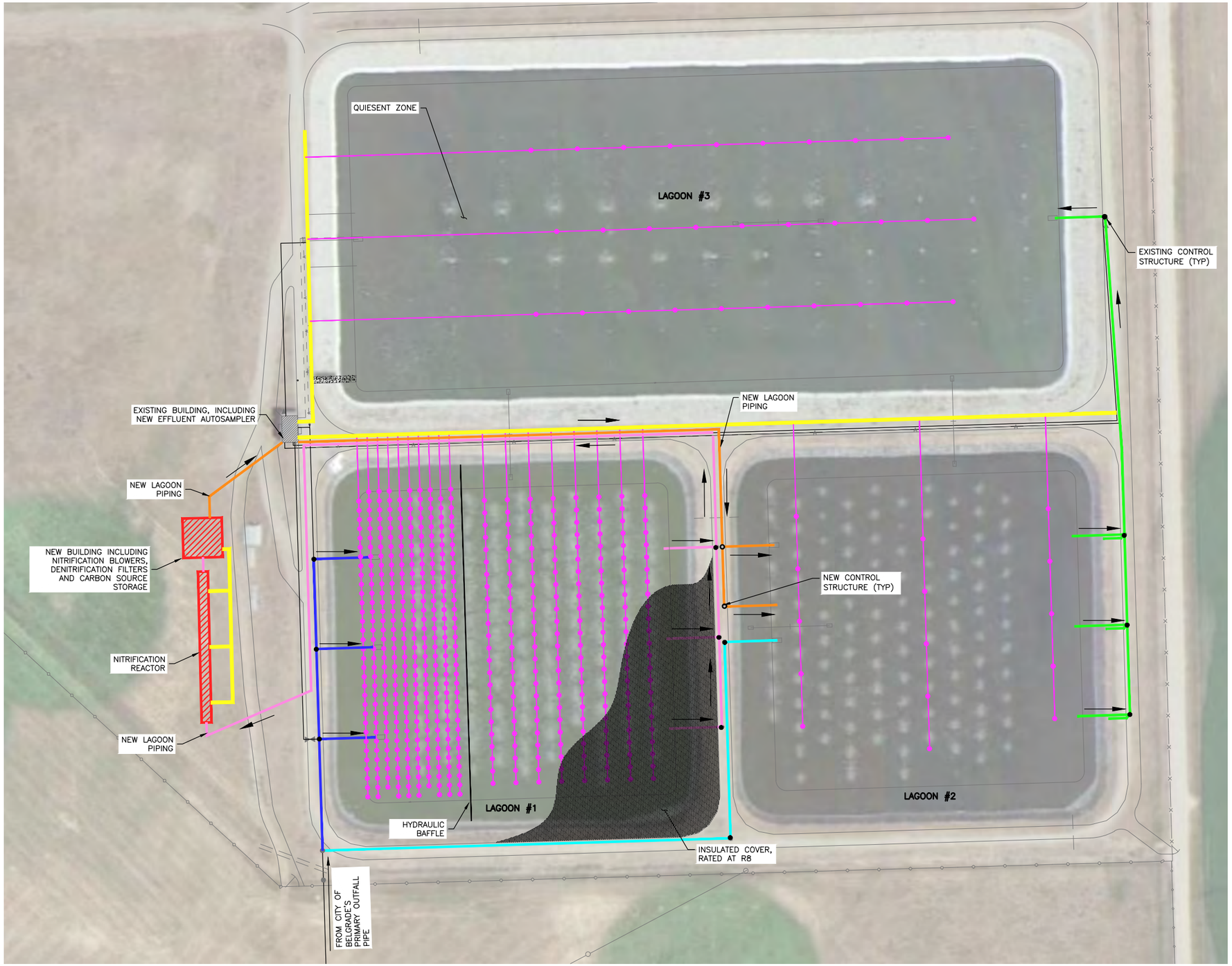
BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MT

ALTERNATIVE T-4A: ADVANCED AERATION
OPTION T-4A(1) LAYOUT

FIG 7-4.DWG

FIGURE 7-4

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 7-4.dwg, 3/27/2018 12:48:34 PM, nmr



LEGEND

- HIGH EFFICIENCY FINE BUBBLE DIFUSER
- NEW AIR HEADER
- AERATION LATERAL
- DISTRIBUTION PIPELINE
- TRANSFER LINE C–2
- TRANSFER LINE B–2
- TRANSFER LINE D–2
- BYPASS PIPELINE
- FLOW DIRECTION

NOTES:

1. SLUDGE SHALL BE REMOVED FROM ALL EXISTING LAGOONS.
2. EXISTING STATIC TUBE AND SURFACE AERATORS SHALL BE REMOVED.
3. EXISTING AIR HEADERS SHALL BE DEMOLISHED.

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ALTERNATIVE T-4A: ADVANCED AERATION OPTION T-4A(2) LAYOUT

FIG 7-5.DWG

FIGURE 7-5

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 7-5.dwg, 3/27/2018 12:49:36 PM, nmr

7.1.5.3 Other Improvements

7.1.5.3.1 Interpond Piping and Controls

The two layout options within this alternative will require slightly different interpond piping. The function and capacity of the Distribution and Bypass pipelines are consistent between the two options. Transfer piping function varies however. Table 7-2 summarizes the design flow rates and the estimated capacities of the piping within each option; calculations are provided in Appendix 7. Pipeline nomenclature is consistent with Figures 7-4 and 7-5. Capacity estimate calculations for each pipeline are described in the following sections. Additionally, some of the existing valves utilized for flow control between ponds will likely need to be modified to control the increased flow.

Table 7-2
Alternative T-4A – Interpond Piping Capacities

Design Flows		
Flow Type	**Flow Rate (gpd)**	
Average Day	1,670,000	
Maximum Month	2,404,000	
Maximum Day	3,323,000	
Peak Hour	5,511,000	
Peak Instantaneous	6,997,000	
Alternative T-4A(1) Estimated Hydraulic Capacities		
Pipeline	**Gravity or Pressurized?**	**Capacity (gpd)**
Distribution Pipeline	Gravity	2,270,000 to 3,940,000
Bypass Pipeline	Gravity	3,490,000
Transfer Line B-1	Gravity	2,660,000
Transfer Line C-1	Gravity	5,950,000
Transfer Line D-1(1)	Pressurized	2,880,000
Alternative T-4A(2) Estimated Hydraulic Capacities		
Pipeline	**Gravity or Pressurized?**	**Capacity (gpd)**
Distribution Pipeline	Gravity	2,270,000 to 3,940,000
Bypass Pipeline	Gravity	3,490,000
Transfer Line B-2	Gravity	1,680,000
Transfer Line C-2(2)	Gravity	3,180,000
Transfer Line D-2(1)	Pressurized	3,312,000

(1) Transfer Line D hydraulic capacity based on an upsized Transfer Pump

(2) Estimated capacity based on maximum water level in Lagoon #3. As water level decreases, capacity will increase.

The following narrative details interpond piping and capacity relevant to Alternative T-4A(1). Pipe nomenclature is consistent with Figure 7-4.

The analysis performed in Chapter 4 indicates the upstream segment of the existing Distribution Pipeline has a capacity of 3.94 MGD. The pipeline diameter and capacity decrease after each valve vault and a fraction of the raw wastewater flow is directed to Lagoon #1. The minimum capacity of the Distribution Pipeline is 2.27 MGD. All sections of the pipeline have adequate capacity to convey the design average day flow and the upstream section pipe segment capacity is larger than the design maximum day flow.

For Alternative T-4, the Bypass Pipeline will only be required if Lagoon #1 must be taken off-line for maintenance issues. Calculations performed in Chapter 4 indicate the minimum capacity of the line is 3.49 MGD. This is larger than the maximum day flow, however less than the design peak hour flow rate. Due to the anticipated infrequent use, the existing capacity of the Bypass Pipeline is considered sufficient to manage the design flow rates.

For this option, wastewater will no longer flow directly from Lagoon #2 to #3. Rather, discharge from Lagoon #2 will flow through the upstream portion of Transfer Line B to Transfer Line A, where it will be transported to the nitrification reactors. Therefore, for the purposes of this option, Transfer Lines A and B will be combined into one pipeline, known as Transfer Line B-1. Transfer Line B-1 is considered a low head system. Based on ground surface elevations in the area, the water surface elevation of the nitrification reactors is assumed to 4404 feet. The water surface elevation of Lagoon #2 is assumed at 4410.9, the existing lagoons maximum water surface elevation. The number of fittings has been conservatively estimated at 30 to account for a possible heat exchanger. The friction head loss through the pipe is estimated at 3 feet. Based on these assumptions, Transfer Line B-1's hydraulic capacity is 2.66 MGD. Due to the high volumes and detention times associated with these lagoons, it is assumed that the peak hour and peak instantaneous flows will be attenuated within the basins. Therefore, the capacity of Transfer Line B-1 will be compared against the design maximum month flow rate. The estimated capacity of Transfer Line B-1 is greater than the design maximum month flow by roughly 200,000 gpd; as such, the transfer line is considered adequately sized for this option. Pipeline calculations are available for review in Appendix 7.

Transfer Line C-1 will rarely be utilized to convey wastewater to Line B-1 in this option, as the tapered aeration will eliminate the availability of parallel flow. However, the existing pipeline will remain as an emergency overflow should water levels within the existing control structures exceed acceptable levels. Assuming open channel flow, the pipeline has a hydraulic capacity of 5.95 MGD. This pipeline is considered to have sufficient capacity.

For Alternative T-4A, Transfer Line D-1 will convey pressurized flow from the denitrification tank to Lagoon #3. It was assumed that the existing Line D would remain; the Transfer Pump was then sized according to existing Line D. The water surface elevation of the denitrification tank is assumed at 4404 feet and Lagoon #3 water surface is equal to the current maximum allowable water elevation, 4415.25 feet. This analysis suggests the Transfer Pump will require

upsizing to pump the projected flows. Preliminary design calculations, available in Appendix 7, calculate the Transfer Pump will need to be sized to provide 2,000 gpm at 40 feet TDH.

7.1.5.3.2 Alternative T-4A(2)

Figure 7-5 illustrates Alternative T-4A(2) and required piping. The following section details applicable piping considerations. The Distribution and Bypass Pipeline discussion presented with Alternative T-4A(1) remains applicable for Alternative T-4A(2).

For Alternative T-4A(2) wastewater will flow through the existing Transfer Lines C and A to the nitrification tank. For the purposes of this option, these two Transfer Lines will be combined into one line, Transfer Line C-2. Line C-2 is considered a low head system. Water surface elevations for Lagoon #1 and the nitrification tank are assumed to be 4410.9 ft and 4404 ft, respectively. With these assumptions, the capacity of the existing Line C-2 is 3.18 MGD. This is greater than the peak month design flow rate by 780,000 gpd. As discussed previously, the volume and detention time of the treatment lagoons is expected to attenuate the peak instantaneous and peak hour flows and interpond piping must be sized to handle the maximum month flows. The existing line is sufficiently sized to convey the projected flows. Calculations are provided in Appendix 7.

Transfer Line D-2 will convey pressurized flow from the denitrification tank to Lagoon #2. As with Alternative T-4A, it was assumed that the existing Line D would remain; and the Transfer Pump was sized accordingly. The water surface elevation of the denitrification tank is assumed at 4404 feet and Lagoon #2 water surface is equal to the current maximum allowable water elevation, 4410.9 feet. These assumptions indicate the Transfer Pump will require upsizing to provide 2,300 gpm at 40 feet TDH. Preliminary design calculations are available in Appendix 7.

Finally, Transfer Line B-2 will transport water between the two storage Lagoons in the option. This pipeline is considered a low head system and flow rates are dependent on water levels within the lagoons. For the purposes of capacity determination, it is assumed water level within Lagoon #2 remains constant at 4410.9 ft. At times when the water level within Lagoon #3 is near the level in Lagoon #2, the capacity of Transfer Line B-2 is estimated at roughly 1.68 MDG, roughly 10,000 gpd greater than the projected average day flow. As the water level within Lagoon #3 decreases, the capacity of Transfer Line B increases. At a water surface elevation of 4407 ft in Lagoon #3, the capacity of the pipe is 3.55 MGD, which is significantly greater than the projected design maximum month flow rate. The bottom of Lagoon #3 is at an elevation of 4397 ft.

7.1.5.3.3 HDPE Liner

Because of questionable treatment plant influent flow data and the absence of treatment lagoon water level data, confirmation of lagoon leakage is recommended prior to any capital improvement projects. Should leakage be confirmed, liner spot repair will most likely be recommended rather than complete liner replacement due to the high cost of replacement. Research performed by

the Geosynthetic Institute indicated exposed HDPE liner has a life expectancy of greater than 36 years. Therefore, the BWTP's linear could remain effective for another 20 years.

7.1.5.3.4 Sludge Removal and Disposal

Removal of accumulated sludge is necessary to install the proposed aeration system. To protect the existing liner, heavy equipment such as a backhoe or frontend loader will not be permitted to remove sludge. Rather, specialty equipment, such as a floating dredge, will be necessary to remove the sludge from the bottom of the lagoon while avoiding further damage to the liner.

As mentioned in Chapter 4, an average sludge depth of 1.55 feet was measured in Lagoon #1 during a June 2015 site visit. It is assumed that there are equal sludge depths in Lagoon #1 and Lagoon #2. H&S Environmental estimated the total sludge volume at 5.6 MG. Calculations performed by the design team using the average end area method estimate the total sludge in the treatment ponds at 5.3 MG. Crisafulli Sludge Removal Systems suggests sludge removal will take approximately one month to complete. Correspondence with Crisafulli representatives and available dredge literature is included in Appendix 7.

During the 2004 treatment lagoon upgrades, the accumulated sludge was removed from the facultative lagoons and land applied to agricultural fields near the treatment plant. As such, sludge dewatering was not necessary. A number of options are available to dispose of the removed sludge including landfill disposal, composting, surface disposal and land application. Final decisions regarding sludge disposal will be made during final design. The selected sludge disposal method must comply with EPA Part 503 requirements as well as all state and county biosolid disposal regulations

7.1.5.3.5 Miscellaneous Improvements

At the request of City staff, Alternative T-4A includes improvements to reduce O&M practices. Relocating the treatment lagoon's level transducer unit from inside control structure 2 will allow for maintenance work on the unit without staff entering the manhole. Additionally, automatic samplers at the plant's influent and effluent will decrease the effort required to report pollutant concentration test results to the DEQ. This will be especially beneficial should sampling frequencies increase during the design life of the new plant. Finally, to ensure the City has the most accurate record of lagoon flows, a new volumetric ultrasonic flow meter should be installed in the existing weir box.

7.1.5.4 Design Criteria

Circular DEQ-2 outlines design criteria for partially mixed aerated lagoons with controlled discharge. Although this alternative is more accurately classified as a complete mix treatment system, there are no formal DEQ design standards for complete mix aerated lagoons. Conversations with Mr. Terry Campbell from the DEQ's Water Pollution Control State Revolving Fund (WPCSRF) indicated similar projects in Montana have been reviewed under the partially mixed aerated lagoons standards. Correspondence with Mr. Campbell are provided in Appendix 7. Table 7-3 summarizes these criteria.

Table 7-3 Treatment Standards for Partially Mixed Aerated Lagoons With Controlled Discharge	
Circular DEQ-2 Criteria	**Standard**
Location	Minimum 1/4 mile from human habitation
Groundwater Separation	Minimum 4 feet from bottom of pond
Bedrock Separation	Minimum 10 feet from bottom of pond
Number of Aerated Cells	3
Recommended Mode of Aeration	Tapered
Minimum System Oxygen Requirements	2.5 lbs O2/ lbs BOD Removed
Minimum Dissolved Oxygen	2.0 mg/l
Depth	10-15 feet
Minimum Detention Time Under Aeration	20 days
Maximum Seepage Rate	6 inches/year
Emergency Storage to Infiltration/ Percolation	30-90
Winter Storage for Irrigation	(1)
Mixing in Aerated Cells	5-10 HP/MG
(1) An annual month-by month water balance must be submitted with each land application plan to determine winter storage	

All proposed upgrades will meet requirements of the Montana Water Quality Act (MWQA) including the DEQ review and approval of the project plans and specifications in accordance with Circular DEQ-2 standards. Additionally, any treatment upgrades must provide sufficient TN removal to comply with the IP beds' total nitrogen loading limits set by the City's groundwater discharge permit. Alternative T-4A has been designed to meet effluent concentration limits discussed in Chapter 5, including 85% TSS and BOD removal and 13.5 mg/l TN. Predicted effluent water quality is summarized in Table 7-4.

Table 7-4 Alternative T-4A Estimated Effluent Quality		
Constituent	**Effluent Concentration (mg/l)**	**Percent Removal**
BOD	30.0	93%
TSS	30.0	89%
TIN	11.0	N/A
TN	13.5	N/A
Ammonia	2.0	N/A

Detailed preliminary design calculations provided by Triplepoint and LEMNA are available in Appendix 7. Option T-4A(1) includes 23.4 days of total detention time in the treatment lagoons. Option T-4A(2) includes a detention time of 12.5 days under aeration. This is under the 20 day detention time standards, however, an insulated cover is included to provide high BOD removal efficiencies. Mr. Terry Campbell of the

DEQ and a LEMNA sales representative indicate similar projects have received DEQ approval in the past.

7.1.5.5 Treatment During Construction

Careful construction planning would be required for this alternative as the existing BWTP would need to remain operational while the proposed upgrades are installed. Simultaneous construction of individual treatment ponds would not be permitted; one treatment pond must stay on-line at all times. Existing piping would allow each treatment pond to be bypassed for construction. Additionally, the storage lagoon would need to be drained, cleared of all sludge and new aeration equipment installed. Construction would be optimal during the summer when ambient air temperatures are elevated and aerobic digestion will happen most efficiently. Nitrification and denitrification reactors can be installed at any time, as their construction is not expected to affect the existing plant operation.

7.1.5.6 Operations and Maintenance

General O&M procedures for the City are not expected to be drastically altered due to Alternative T-4A. Improvements such as an automatic sampler and VFD to control blower run times based on real time DO concentrations will decrease required labor and energy. However, the addition of the nitrification and denitrification reactors will likely increase O&M procedures and costs. The added blowers, possible heat exchanger and use of organic carbon will also add to the overall O&M costs. The following sections detail the anticipated primary changes to the BWTP annual O&M budget. Estimated costs at design conditions are summarized in Table 7-5. Detailed O&M estimate calculations are available in Appendix 7.

Table 7-5
Alternative T-4A
Annual Operations and Maintenance Budget

Description	Quantity	Unit	Unit Cost	Total Cost
Staffing	3	FTE	$60,000	$180,000
Utilities	1	LS	$247,000	$247,000
General Maintenance and Repairs	1	LS	$200,000	$200,000
Chemical Additives	1	LS	$124,500	$124,500
Total Annual O&M Budget				**$751,500**
Real Interest Rate				**0.20%**
Present Worth for 20 Years (rounded to the nearest thousand)				**$14,719,000**

7.1.5.6.1 Staffing Requirements

Minimal staffing changes are anticipated due to the addition of nitrification and denitrification reactors with blowers and chemical feed. It is difficult to accurately predict future staffing requirements for the City of Belgrade as the existing treatment plant is the largest biological lagoon treatment system in the State. *The Northeast Guide for Estimating Staffing at Publicly and Privately-Owned*

Wastewater Treatment Plants, published by the New England Interstate Water Pollution Control Commission was referenced to estimate staffing requirements. The manual estimates 3 full time employees (FTE) will be needed to run and maintain the new treatment plant. Detailed estimates are included in Appendix 7. At an hourly rate of $30 to include salary, insurance and payroll taxes, $60,000 per year per FTE is needed for staffing costs.

7.1.5.6.2 Carbon Source

The required denitrification carbon source will elevate the annual O&M costs further. An estimated 365 gpd of organic carbon will be fed into the denitrification reactors. Proprietary formulations like MicroC cost about $2.10 per gallon; this would equate to an annual chemical cost for the City of $279,773. Although methanol would require additional safety precautions, unit costs would be approximately $1.30 per gallon. This results in an annual chemical cost of $173,192 at design conditions. For the purposes of budgetary O&M costs, the required carbon feed cost has been based on the cost of the methanol. Should the City elect to go with a proprietary formula, O&M cost could increase by $100,000 per year.

For the sake of comparison, current average day flow is estimated at 716,737 gpd, requiring 157 gpd of organic carbon for denitrification. At $1.30 for methanol, the annual O&M cost for a carbon sources assuming current conditions is $75,000. For the purposes of preliminary planning, the average annual cost of the required carbon assuming full build out and current conditions, $124,000, will be used for budgetary O&M costs.

7.1.5.6.3 Energy Consumption

Power will need to be supplied to the blowers, transfer pump and potentially a heat exchanger. Alternative T-4A requires all impounded wastewater to be pumped from the denitrification reactor to the storage lagoon; gravity flow will no longer be possible. Power consumption of the Transfer Pump will increase as a result of this alternative. Conversations with Industrial Solutions Inc. sales representatives suggest a 40 HP motor will be required. The pump size is estimated at 2,000 gpm (2.88 MGD). The design average day flow is 1.67 MGD, or 58% of the design pump capacity. It is estimated that the pump will run for 14 hours per day at design capacity (24 hrs/day * 58%=14 hrs/day). Assuming an electrical cost of $0.10 per kW-hr, the estimated annual cost of the Transfer Pump is $15,300.

Blower energy costs were estimated based on preliminary designs provided by both Triplepoint and LEMNA. Daily blower run times were approximated based on minimum required power and the design blower motor. For example, the minimum required motor size for the treatment lagoons, according the Triplepoint calculations, is 252 HP. Triplepoints' preliminary design suggests 3-100 HP blowers for a total blower power to the treatment ponds of 300 HP; the required HP is 84% of the design power. Therefore, it is estimated that the treatment lagoon blowers will run 20.16 hours/day (24 hr/day * 84%) at design conditions. This process was repeated for the nitrification reactor and storage lagoon blowers for both the LEMNA and Triplepoint systems. The resulting annual

energy requirement for the blowers at design conditions is between 2,600,000 kW-hr and 3,300,000 kW-hr. This equates to an annual electricity cost at design conditions of $260,000 to $330,000.

For comparison purposes, blower power consumption was also calculated for current conditions. It was assumed that blower run times are proportional to flow rate. The current average day flow of 716,737 gpd is 43% of the design average day flow. As such, blower run times would be decreased to about 8 hours/days (20.16 hr/day * 43%). Current annual energy costs were calculated for both LEMNA and Triplepoint's preliminary designs. Assuming an electricity cost of $0.10 per kW-hour, roughly $136,000 to $163,000 would be required in annual energy costs to power the blowers for the treatment lagoons, storage lagoon and nitrification reactor under current conditions. For comparison, annual energy costs for the BWTP were calculated for 2013 to 2015, assuming $0.10 per kW-hr. The average annual cost for these three years is approximately $136,000. The increased energy costs associated with the new system are due to the additional bowers required to serve the nitrification reactor.

The heat exchanger associated with Alternative T-4A(1) will only operate when water temperatures are below 42°F (4°C). Calculations were performed assuming the heat exchanger will be utilized from November to February, or 120 days/year. To ensure a conservative estimate, annual costs were calculated based on electrical costs. Natural gas would result in a noticeable decrease in utility costs. An estimated $514,000 in annual electricity costs will be required for the optional heat exchanger. Should the City elect to forgo thermal regulation by heat exchanger, insulated covers over the treatment ponds will be required. For the preliminary annual O&M budget presented in Table 7-4, **utility costs associated with the heat exchanger are not included**.

At full build out, the estimated annual energy cost, including energy required for the blowers and transfer pump is $344,000. For planning purposes, the average energy cost between today's conditions and full-build out, $247,000, will be used to estimate the annual O&M budget.

7.1.5.6.4 General Maintenance and Repairs

Alternative T-4 is not expected to drastically affect the annual cost for general maintenance and repairs. The City of Belgrade provide water and sewer financial records for fiscal years 2013 to 2014. These records indicated the City spent $199,000 and $209,000 on supplies and purchased services for the sewer system in 2013 and 2014, respectively. Although it is believed that a portion of those funds were allocated to the collection system, a conservative $200,000 is included in the Alternative T-4A's annual O&M budget for general maintenance and repairs. Financial records are included in Appendix 7.

7.1.5.6.5 Cost Estimate

Planning level capital cost are presented in Table 7-6. Capital costs estimates include all anticipated items required for the successful installation of the treatment plant upgrades defined in this section. Total estimated construction costs for Alternative T-4A include an elevated unit cost for the new building to

account for required fire suppression systems, should the City elect to utilize methanol as the denitrification carbon source. Non-flammable carbon sources will decrease capital cost, but have a significant impact on the annual O&M budget, previously discussed. The line item for thermal regulation is based on pricing for an insulated cover over the treatment ponds. The City may choose to provide more precise temperature control of the impounded water. This is expected to increase capital costs as well as the annual utility costs. The estimated future costs for Alternative T-4A include 15% contingency, 25% for engineering, legal and administrative fees, and 10% for undeveloped design details. **The estimated total construction cost for Alternative T-4A is $18,040,000.**

Table 7-6
Alternative T-4A – Construction Cost Estimate

Description	Quantity	Unit	Unit Cost	Total Cost
Mobilization	7	%		$755,305
Sludge Removal, Transport and Disposal	27,500	CY	$25	$687,500
Demo Existing Air Header	1,500	LF	$15	$22,500
Demo Existing Aerators	1	LS	$7,500	$7,500
Spot Repair Liner	1	LS	$23,000	$23,000
New Air Headers	1	LS	$115,000	$115,000
New Advanced Aeration Equipment	1	LS	$1,957,500	$1,957,500
Earthwork	1	LS	$100,000	$100,000
Yard Pipe	1	LS	$200,000	$200,000
Nitrification Equipment and Installation	1	EA	$2,392,500	$2,392,500
Denitrification Equipment and Installation	1	LS	$1,740,000	$1,740,000
Carbon Storage Tank and Feed Pump	1	EA	$20,000	$20,000
New Building	1	LS	$400,000	$400,000
New Transfer Pump	2	EA	$25,000	$50,000
Modify Existing Control Structures	1	LS	$25,000	$25,000
Modify Level Transducer	1	EA	$3,000	$3,000
New Influent Flow Meter	1	EA	$10,000	$10,000
Automatic Water Sampler	2	EA	$10,000	$20,000
Thermal Regulation	1	LS	$435,000	$435,000
Headworks Facility	1	LS	$1,700,000	$1,700,000
Electrical	1	LS	$500,000	$500,000
Startup and Commissioning	1	LS	$150,000	$150,000
Layout and Construction Staking	1	LS	$20,000	$20,000
Construction Materials Testing	2	%		$211,570
			Subtotal	**$11,545,375**
			Contingency 15%	$1,731,806
			Undeveloped Design Details 10%	$1,154,537
			Total Construction Estimate	**$14,431,719**
			Administrative, Engineering and Legal 25%	$3,607,930
			Estimated Cost (rounded to the nearest thousand)	**$18,040,000**

7.1.5.7 Alternative T-4B: Sequencing Batch Reactors with Facultative Biosolids Storage Lagoons

Alternative T-4B evaluates a Sequencing Batch Reactor (SBR) for secondary treatment and repurposes existing Lagoons #1 and #2 as biosolids storage basins. The storage basins would operate as facultative lagoons with an aerated water-cap for odor control.

7.1.5.7.1 Sequencing Batch Reactor (SBR)

SBRs are an operator-friendly alternative as the process is controlled by an automated controls system and have relatively few pieces of equipment that require routine maintenance. SBRs are capable of removing nearly all BOD and TSS, as well as some nitrogen and phosphorus. Many brands of SBR exist on the market and new technologies are being researched to improve the technology. Specific brands of SBR's would be evaluated more closely in preliminary engineering. This alternative provides the Engineer's Opinion of Probable Construction Costs (EOPCC) and annual O&M costs.

SBRs minimize the operational footprint of the secondary treatment process by completing all cycles of treatment in a single reactor. This eliminated the need for secondary clarifiers. SBR operations are controlled by a programmable logic controller (PLC) housed in a control panel. The PLC includes some monitoring functionality and orchestrates the timed series of treatment cycles. The treatment cycles of an SBR vary slightly by name and duration from one manufacturer to the next, but generally consist of fill (or fill/react), react, settle, and decant cycles, as shown in Figure 7-6. Fill/react and react cycles typically operate under aerobic conditions; however an anoxic time series may be programmed for denitrification.

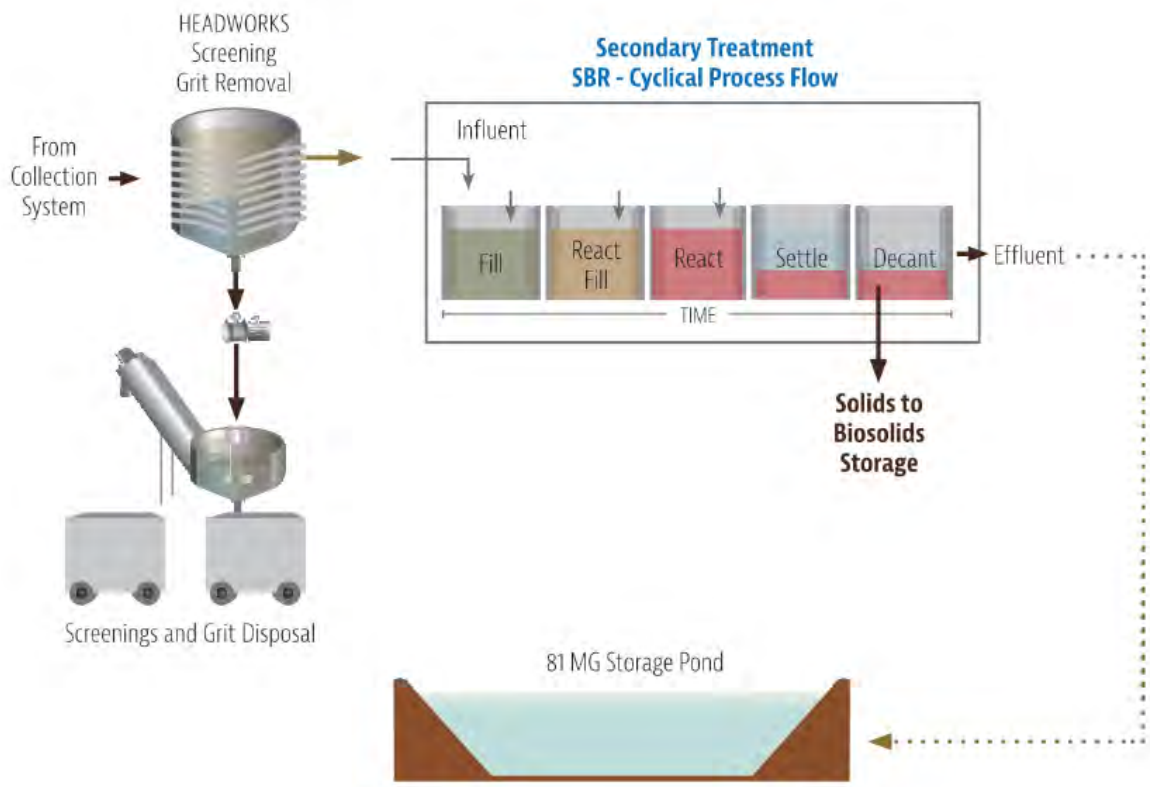


Figure 7-6: Process Flow Diagram for Sequencing Batch Reactor w/ Facultative Lagoon

All of the SBR cycles occur within the same basin, unlike conventional activated sludge processes that utilize individual basins or zones of basins to achieve similar treatment on a continuous waste stream. SBRs are traditionally a batch process that perform treatment on a finite quantity of water before the treated effluent is decanted to downstream processes. However, because municipal wastewater influent flow is continuous, SBR plants often require three or more SBR basins. This allows influent flow to be continuously directed to a basin during its "fill" or "fill/react" mode. Some SBR manufacturers allow for continuous influent to the basins no matter the cycle time or sequence, eliminating the need for equalization and allowing as few as two basins. One such manufacturer is Xylem–Sanitaire, developers of the Intermittent Cycle Extended Aeration System (ICEAS) process.

Aerobic Granular Sludge (AGS) is a growing technology for use in SBRs. AGS enables improved nitrogen and phosphorus treatment and requires only minor modifications to SBR systems to encourage microorganisms to granulate. This creates a denser population of biomass, with anaerobes, nitrifiers, and denitrifiers populating various layers within the same sludge particle or granule. Aqua-Aerobics, one of the longest running SBR equipment manufacturers, has recently developed AGS for its systems, and is developing a process guarantee for pollutant concentrations for BOD, TSS, TN and TP less than or equal to 10 mg/l, 10 mg/l, 5 mg/l, and 1 mg/l, respectively. Chemical addition can achieve TP of less than 0.5 mg/L. This technology is not yet mature enough for purposes of

this planning document; however, depending on the timing of the potential upgrade, AGS may be evaluated further. This technology would likely reduce the footprint size of the SBR Basins and reduce capital costs. Higher mixed liquor suspended solids (MLSS) concentration in a smaller volume would be achieved by increasing density and improving settleability.

Benefits cited for the use of SBR technology often include a smaller footprint size and ease of operability. It is expected that an SBR treatment system will perform reliably for the City of Belgrade, provided that the City's discharge permit continues to resemble the theoretical discharge permit limits summarized below:

Theoretical Discharge Permit Limits for SBR:

- Total Nitrogen: 13.5 mg/L
- Total Phosphorus: 3.0 mg/L
- $Q_{Effluent}$: up to 1.93 MGD*
  - *Discharge capacity allotted before exceeding Nitrogen mass loading.

7.1.5.7.2 Facultative Biosolids Storage Lagoon

The biological mass of cells in the SBR system, like any biological population, proliferates, requiring the older microorganisms to be removed from the system to make room for the younger, more active organisms. The wasted biomass, commonly referred to as waste activated sludge (WAS), is usually stabilized further in large digesters, either aerobically or anaerobically. Given the high cost of digested sludge disposal in the Gallatin Valley and the City of Belgrade's access to large existing lagoons for storage, Alternative T-4B repurposes Lagoons #1 & #2 as facultative storage lagoons. Figure 7-7 illustrates the proposed storage lagoon.

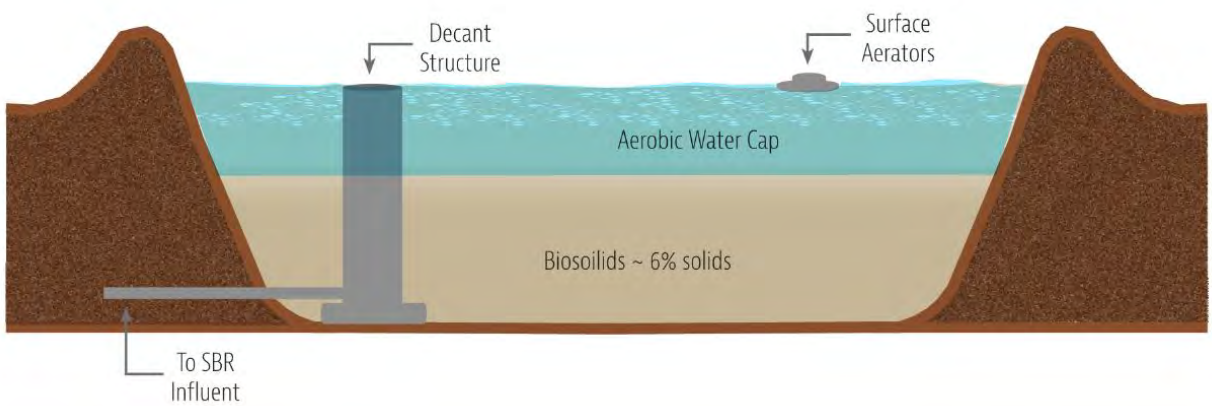


Figure 7-7: Facultative Storage Lagoon (Biosolids Storage)

Solids can be stored for up to 20-years in facultative lagoons where solids are naturally stabilized either aerobically or anaerobically and pathogens destruction is effective. Surface aerators will be operated to maintain an aerobic layer,

referred to as a water-cap, near the top surface of the lagoon. The water-cap will help control any nuisance odors emanating from the ponds. Given the magnitude of surface area, storage volume available, and the anticipated WAS volume, the loading rate of these facultative lagoons is expected to be relatively low, approximately 6 lb volatile suspended solids (VSS)/10^3 ft^2- day. This will also help minimize odors. As the solids settle to the bottom of the lagoon, the cleaner water can be decanted off the top through a decant structure and returned to the head of the plant for treatment and disposal. Table 7-7 summarizes the estimated solids production. Preliminary calculations of solids production and accumulations rates indicate the solids would have to be removed and disposed of in these facultative lagoons approximately every 7 to 8 years, possibly greater.

Table 7-7 Estimated Solids Production	
WAS Produces (lb/day)	4,872
Volatile Suspended Solids Content (VSS):	75%
Solids Destruction of VSS:	20%
Settled Solids Concentration*:	6%
Volume of WAS Production (gal/day):	8,275
Million-Gallons/Year	3.02

7.1.5.7.3 Basic Equipment List

- Headworks Facility:
  - Mechanical Perforated Screens
  - Washer Compactor
  - Grit Removal Equipment
  - Influent Flow Sampler
- Facultative Lagoons:
  - Surface Aerators
- SBR Equipment
  - Air Compressors (Blowers)
  - Air Diffusion Equipment
  - Submersible Mixers
  - Decanters
  - WAS Pumps
  - Instrumentation & Controls.
  - Motor Control Center (MCC)

7.1.5.7.4 Map

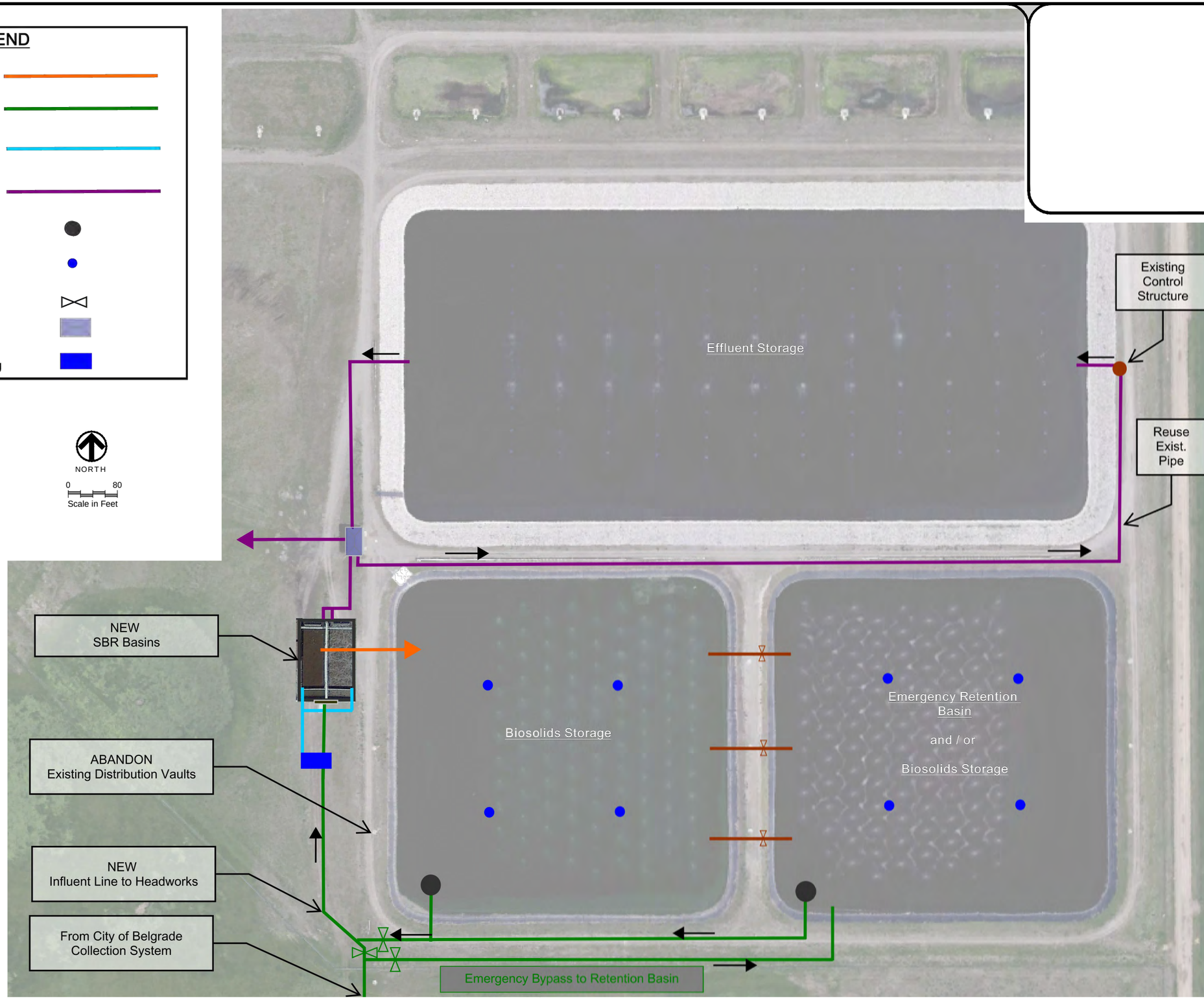
Figure 7-8 presents a site layout for Alternative T-4B.

LEGEND

- Waste Activated Sludge
- Gravity Sewer
- New Air Header
- Treated Effluent to Eff. Storage or Disposal
- Decant Structure
- Surface Aerators
- Gate Valve
- Existing Pump & Control Building
- New Headworks & Blower Building

NORTH

0 80
Scale in Feet



PRELIMINARY
NOT FOR CONSTRUCTION
##########

AE2S

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
BELGRADE, MT

ALTERNATIVE T-4: SBR WITH STORAGE LAGOON SITE LAYOUT

DRAWING TYPE	FIGURE
PREPARED BY	XXX
CHECKED / APPROVED	### / ###
DATE	MARCH 2018
PROJECT NUMBER	P13065-2016-000
SHEET	# of ##
DRAWING	7-8

Advanced Engineering and Environmental Services, Inc. ● 1288 N 14th Ave, Unit 103 Bozeman, MT 59715 ● (t) 406-219-2633 (f) 406-219-2635 ● www.ae2s.com

Layout: Layout1
File: S:\TD&H Prime Contracts\Belgrade, City of\P13065-2016-000 - TD&H Belgrade WW Facility Plan\CAD Dwgs\01-Civil\CS-SP_AIT-4.dwg
Plotted By: Twila Kemp Date: Monday, April 16, 2018
Last Saved By: Twila Kemp Date: Monday, April 16, 2018 8:35:24 AM

7.1.5.7.5 Treatment During Construction

Normal operations of the existing aerated lagoons can be maintained throughout construction until the influent pipe is directed to the new SBR basins upon start-up. Contractors will likely have additional time after start-up to convert Lagoons #1 and #2 to facultative biosolids storage lagoons as WAS is not expected to be wasted immediately. Improvements to Lagoons #1 and #2 would include the same liner spot repairs discussed in Alternative T-4A. Removal of the existing solids layer in Lagoons #1 and #2 is also recommended.

7.1.5.7.6 Operations & Maintenance

Major O&M costs will result in the electricity costs necessary to operate the equipment. Major electrical equipment includes SBR blowers, submersible mixers (depending on exact process), fine screens in pretreatment building, transfer pumps, submersible WAS pumps, and surface aerators for facultative lagoons.

Staffing expense requirements have been estimated based on a literature review of *The Northeast Guide to Estimating Staffing at Publicly and Privately-Owned Wastewater Treatment Plants.* This guide provides an objective source for estimating staffing costs. Results are often considered conservative estimates of the number of FTE required. Further discussion on staffing and labor expenses of provided after the evaluation of Alternative T-5 is presented. O&M costs were estimated using 4 FTE; however. Estimated annual O&M budgetary costs are presented in Table 7-8.

Table 7-8
Alternative T-4B
Annual Operations and Maintenance Budget

Description	Quantity	Unit	Unit Cost	Total Cost
Staffing Expenses	4	FTE	$60,000.00	$240,000
Equipment O&M	1	LS	$212,755.68	$212,756
Utilities	2.02e10	kW-hr	$0.11	$216,848
			Total Annual O&M Budget	**$669,600**
			Real Interest Rate	**0.20%**
Present Worth for 20 Years (rounded to the nearest thousand)				**$13,115,000.00**

7.1.5.7.7 Energy Consumption & Utility Cost Validation

Energy consumption was estimated at the average design conditions. Table 7-9 lists major electrical equipment along with horsepower and runtime to estimate total electrical loads. A price of $0.10/kW-hr was used to estimate total annual utility costs.

Table 7-9 Alternative T-4B Annual Electrical Utility Cost				
Equipment	**HP**	**kW**	**Runtime (hr/day)**	**kW-hr/Year**
Screening	2.0	1.5	4	2,177
Grit Removal				
Grit Removal	2.4	1.8	4	2,628
Grit Pump	5.0	3.7	4	5,444
Effluent Pumping	25.0	18.6	24	163,308
SBR System				
Blowers	120	89.5	18	122,481
Mixers	20	14.9	1.6	8,710
WAS Pumps	2.5	1.9	1.0	680
Decanters	0.5	0.4	1.5	204
Facultative Lagoons				
Surface Aerators (x8)	30 (x8)	22.4 (x8)	18 (x8)	1,567,760
Lighting & Other Misc. Loads		45.0	12	197,100
			Total Annual kW-hr	**2,168,478**
			Cost [$/kW-hr]	**$0.10**
			Annual Electrical Utility Cost	**$216,847.76**

7.1.5.7.7 Cost Estimate

Planning level capital costs are presented in Table 7-10. Financial consideration should not only be given to the total estimated construction cost, but also the financial administrative costs, engineering fees, and legal costs of working with bond council. Estimated project costs total $17,096,000.

Additionally, a new emergency may be required for the new facility. If a new electrical generator is required, capital costs would be expected to increase by $500,000 to $800,000.

Table 7-10 Alternative T-4B: SBR with Facultative Biosolids Storage Lagoon Construction Cost Estimate			
Construction Costs			
General Conditions			
Bonding / Insurance / Project Mgmt & Admin. / Mobilization			$715,800
Site Work			
Site Management / SWPPP		$53,200	
Solids Handling & Misc. Demo		$740,500	
Headworks		$12,600	
SBR		$353,900	
Site Improvements - (Grading & Site Piping)		$164,925	
SUBTOTAL: SITE WORK			$1,325,100
Structural & Architectural			
Headworks		$544,000	
Control Building Upgrades		$101,800	
SBR		$ 3,400,000	
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$4,045,800
Process Equipment & Piping			
Headworks		$633,100	
Control Building Upgrades		$95,490	
SBR		$1,834,100	
Installation & Start-Up		$768,800	
SUBTOTAL: EQUIPMENT & FURNISHINGS			$3,331,500
Mechanical			
Headworks		$14,300	
Control Building Upgrades		$9,000	
Installation & Start-Up		$3,495	
SUBTOTAL: MECHANICAL			$26,800
Electrical			
Electrical / Instrumentation & Controls			$1,496,400
SUBTOTAL			**$10,941,400**
Undeveloped Design Details	10%		$1,094,200
Construction Contingencies	15%		$1,641,200
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$13,676,800**
NON-CONSTRUCTION COSTS			
SUBTOTAL: ADMINISTRATIVE / ENGINEERING / & LEGAL			$3,420,000
TOTAL ESTIMATED PROJECT COST			**$17,096,800**

7.1.6 Alternative T-5: Greenfield Mechanical Treatment

The City of Belgrade currently operates its lagoon treatment facility on the grounds of the Bozeman Yellowstone International Airport (BZN). For comparison purposes, Alternative T-4 should be weighed against the cost and logistics of relocating the facility to a new, greenfield, location. The City of Belgrade would be required to purchase additional land to this alternative. This alternative has pros and cons for the City.

Pros of Greenfield Treatment Facilities:

- Not limited by requirements established by BZN.
- Not investing in facility upgrades on property that is reliant upon a third-party agreement.
- Relocate facility away from community development – relieving the City from nuisance odor complaints.

Cons of Greenfield Treatment Facilities:

- Greater expense for construction & overall project costs.
- Greater investment in biosolids handling costs:
    - Capital costs increases due to mechanical digestion and biosolids facilities.
    - O&M & Disposal costs increase as on-going maintenance and labor costs.
- May require transition to surface water discharge.
    - Increases Capital & O&M costs for disinfection purposes.

Three secondary treatment processes were evaluated for a greenfield facility. Because a greenfield mechanical treatment facility may need to rely on surface water discharge for disposal (as opposed to the existing ground water disposal), more strict discharge permits were considered. The evaluation considers three separate discharge permits, each requiring a different quality of effluent substantiated by theoretical conditions upon which the final discharge permit may be based. Each alterative, T-5A; T-5B; and T-5C, is designed to meet a theoretical surface water discharge permit having TN and TP limits of progressive stringencies.

Alternative T-5: Processes Considered & Respective Theoretical Discharge

- Alternative T-5A: Sequencing Batch Reactor
    - Total Nitrogen: 13.5 mg/L
    - Total Phosphorus: 3.0 mg/L

- Alternative T-5B: 5-Stage Bardenpho
    - Total Nitrogen: 8.0 mg/L
    - Total Phosphorus: 0.5 mg/L

- Alternative T-5C: Membrane Bioreactor (MBR**)**
    - Total Nitrogen: 6.0 mg/L
    - Total Phosphorus: 0.3 mg/L

The results of this mechanical treatment evaluation will provide the City of Belgrade the following information:

- A planning-level estimate of cost for upgrading its treatment process to a greenfield treatment facility if site relocation were to be considered.
- Estimated O&M costs for treatment, operations, and biosolids management
- Estimated quantities of biosolids production.
- EOPCC for the following:
    - Overall Facility of Alternatives T-5A; T-5B; & T-5C
    - Individual Facilities as follows:
        - Control Building
        - Headworks Facilities
        - Secondary Treatment
        - Disinfection Facility
        - Biosolids and Digestion Facility

Alternative T-5 was evaluated with the same basic hydraulic and nutrient loading data provided in the previous treatment alternatives.

7.1.6.1 Alternative T-5A Sequencing Batch Reactor

This alternative includes the same secondary process detailed in Alternative T-4B. Please refer to Alternative T-4B for discussion on the secondary treatment process involved in SBRs.

7.1.6.1.1 SBR

The process flow diagram for Alternative T-5A is provided below in Figure 7-9. In contrast to Alternative T-4B, Alternative T-5A includes effluent disinfection by a UV process as well as mechanical digestion.

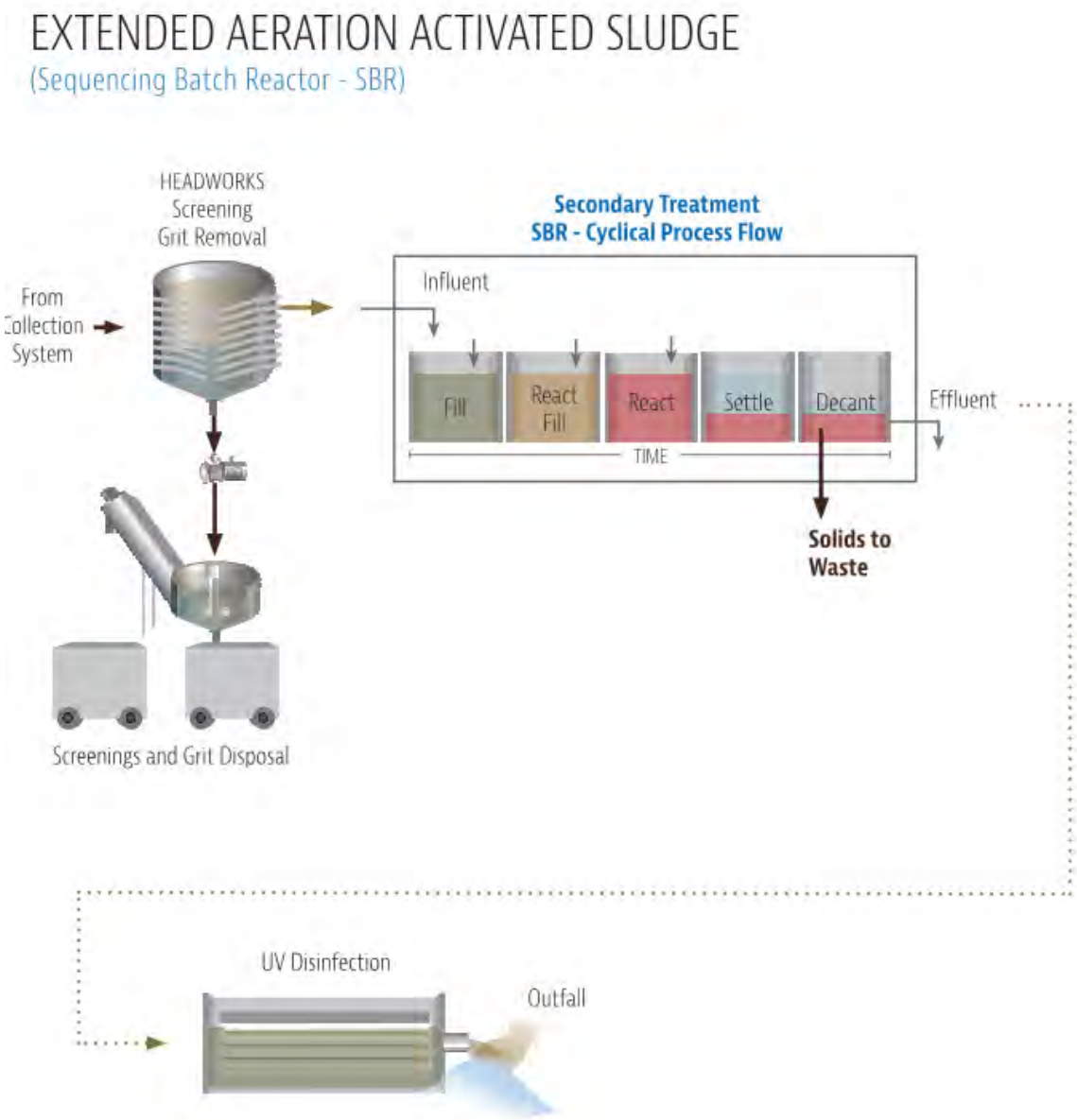


Figure 7-9: Alternative T-5A: Sequencing Batch Reactor with Mechanical Biosolids Digestion

7.1.6.1.2 UV Disinfection

Disinfection would be required for surface water discharge to protect the public from biological contaminants such as *E. coli*. UV works by destroying the DNA of bacteria and thereby prevents them from further proliferation. UV is often preferred to chlorination/dichlorination as no chemicals are involved in the process and the concern over discharging chemicals to a receiving stream is removed. Chlorine residuals are regulated by DEQ to reduce toxicity to aquatic wildlife. Typically, surface water discharge permits allow for two seasons with separate *E. coli* discharge limits, winter and summer. Summer will have a much lower *E. coli* discharge limit as it is the time when the public is most likely to come in contact with streams carrying discharged effluent. *E. coli* limits are

measured in Colony Forming Units / 100 mL [CFU/100 mL]. Testing for *E. coli* limits are typically completed in the facilities laboratory, but can also be completed by a third-party testing facility.

7.1.6.1.3 Digestion

Biosolids consideration and processes are considered further in a future portion of this evaluation of Alternative T-5.

7.1.6.1.4 Basic Equipment List

- Headworks Facility:
  - Mechanical Perforated Screens
  - Washer Compactor
  - Grit Removal Equipment
  - Influent Flow Sampler
- SBR Equipment
  - Air Compressors (Blowers)
  - Air Diffusion Equipment
  - Submersible Mixers
  - Decanters
  - WAS Pumps
  - Instrumentation & Controls.
  - Motor Control Center (MCC)
- UV Disinfection Facility:
  - UV Lamps and Banks
  - Effluent Flow Sampler
- Digestion & Biosolids:
  - Mechanical Thickening Unit
  - Digester Feed Pumps
  - Polymer Feed Pumps
  - Air Compressors (Blowers)
  - Jet Aeration Headers
  - Aerobic Digester Mixing Pump
  - Digested Sludge Transfer Pumps
  - Sludge Dewatering Equipment (Screw Press)

7.1.6.1.5 Cost Estimate

Table 7-11 provides a cost estimate for the proposed greenfield SBR facility.

Table 7-11 Alternative T-5A: Greenfield SBR Facility Construction Cost Estimate		
CONSTRUCTION COSTS		
General Conditions		
Bonding / Insurance / Project Mgmt. & Admin. / Mobilization		$1,748,600
Site Work		
Land Acquisition	$500,000	
Site Management / SWPPP	$62,600	
Headworks	$12,600	
Control Building	$0	
SBR	$353,900	
UV Disinfection	$11,000	
Digestion & Biosolids	$53,900	
Site Improvements - (Grading & Site Piping)	$194,130	
SUBTOTAL: SITE WORK		$1,188,100
Structural & Architectural		
Headworks	$544,000	
Control Building	$1,334,000	
SBR	$3,400,000	
UV Disinfection	$274,000	
Digestion & Biosolids	$1,867,000	
SUBTOTAL: STRUCTURAL & ARCHITECTURAL		$7,419,000
Process Equipment & Piping		
Headworks	$633,100	
Control Building	$1,023,900	
SBR	$1,723,700	
UV Disinfection	$314,819	
Digestion & Biosolids	$5,234,000	
Installation & Start-Up	$2,678,900	
SUBTOTAL: EQUIPMENT & FURNISHINGS		$11,608,400
Mechanical		
Headworks	$14,300	
Control Building	$9,000	
SBR	$0	
UV Disinfection	$9,500	
Digestion & Biosolids	$26,300	
Installation & Start-Up	$8,865	
SUBTOTAL: MECHANICAL		$68,000

Table 7-11 (Cont)			
Alternative T-5A: Greenfield SBR Facility			
Construction Cost Estimate			
Electrical			
Electrical / Instrumentation & Controls		$4,696,400	
SUBTOTAL			**$26,728,500**
Undeveloped Design Details	10%		*$2,672,900*
Construction Contingencies	15%		*$4,009,300*
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$33,410,700**
NON-CONSTRUCTION COSTS			
SUBTOTAL: ADMINISTRATIVE / ENGINEERING / & LEGAL			$8,353,000
TOTAL ESTIMATED PROJECT COST			**$41,763,700**

7.1.6.2 Alternative T-5B: 5-Stage Bardenpho w/ Chemical Phosphorus Removal

Biological nutrient removal (BNR) refers to the process of reducing nitrogen (N) and phosphorus (P) using biological treatment processes. Nitrogen reduction requires cyclical anoxic and aerobic environments. Phosphorus reduction requires cyclical anaerobic and aerobic environments. Removal of both N and P using BNR alone can be challenging because the bacteria responsible for denitrification and phosphorus uptake both compete for the same food source, readily biodegradable compounds. Therefore, it is common to include chemical phosphorus removal, using coagulants and tertiary filtration for reduction of P at facilities where less than 0.5 mg/L TP are required. For the purposes of this evaluation, BNR with chemical phosphorus removal and tertiary filtration was deemed representative of a facility that would achieve limits of less than 10mg/l and 1 mg/L of TN and TP, respectively.

The 5-Stage Bardenpho (Bardenpho) process is a potential mechanical treatment option to achieve BNR reliably. There are several other conventional activated sludge configurations capable of achieving BNR (e.g., Oxidation Ditches, VIP, UCT processes), which could be evaluated for optimization if the City is faced with a 10 mg/l and 1 mg/l TN and TP limit at some point in the future, but the Bardenpho process was selected as a reasonable representation for this permitting scenario. The Bardenpho process is currently in use at the City of Bozeman Water Reclamation Facility (WRF).

7.1.6.2.1 <u>5-Stage Bardenpho Process Flow</u>

Please refer to Figure 7-10 for a PFD for Alternative T-5B: 5-Stage Bardenpho.

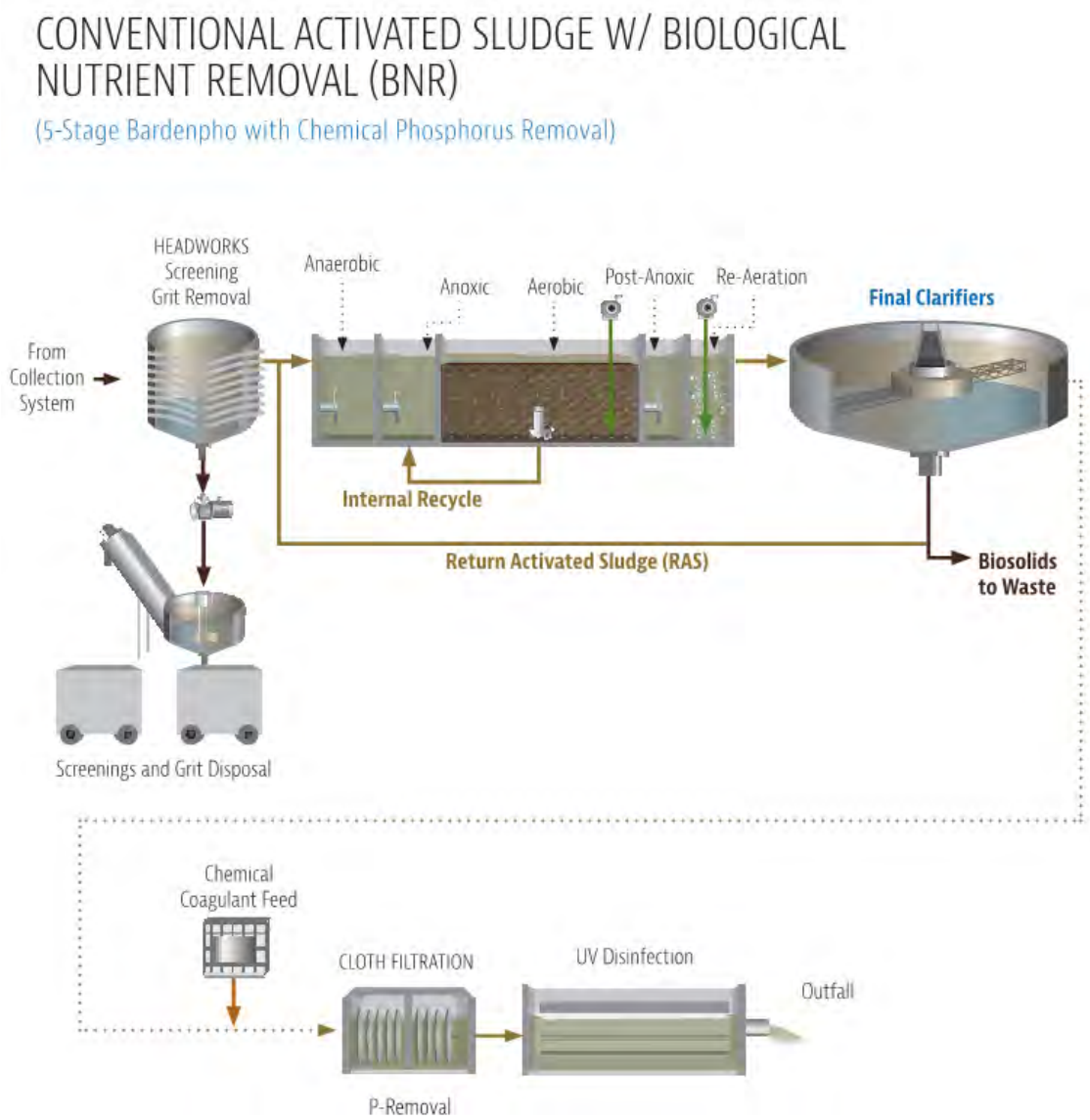


Figure 7-10: Alternative T-5B: 5-Stage Bardenpho Process with Chemical Phosphorus Removal

The Bardenpho system includes five different zones, each with strategically selected environments: anaerobic, pre-anoxic, aerobic, post-anoxic and aerobic. As the waste stream progresses through the treatment trains, the different environmental conditions trigger metabolic reactions in the suspended growth biological treatment process for reduction of nitrogen, phosphorus, and carbon.

Mixed liquor from the first aerobic zone is recycled to the pre-anoxic zone to provide nitrate for denitrification. Mixed liquor from the aerobic zone is recycled to the anoxic zone to provide nitrate for denitrifying microorganisms. Return Activated Sludge (RAS) is recycled to the head of the anaerobic zone, in order to cultivate Phosphorus Accumulating Organisms (PAOs).

Denitrification occurs in both the pre-anoxic and postanoxic zones. Low nitrate levels in the RAS recycle to the anaerobic zone enables PAOs to thrive and improve phosphorus

removal. In the final aerobic zone, labeled in the diagram as Re-Aeration, the dissolved oxygen is increased to reduce phosphorus release during secondary clarification.

Coagulation and tertiary filtration are provided downstream of the secondary clarifiers, for improved solids and phosphorus removal. Cloth filtration was selected for conceptual design and costing purposes for Belgrade. Other filtration technologies exist but cloth media has a substantial market share in wastewater treatment, and is a relatively inexpensive approach. Cloth filtration is a representative technology for the basis of this evaluation. Reduction of total phosphorus to less than 1.0 mg/L with cloth filtration uses coagulation to capture soluble phosphorus in floc particles, which are too large to pass through the cloth media. Utilizing cloth filtration for P-removal, discharge limits of less than 1 mg/L TP and 5 mg/L TSS can be expected.

It is worthy note the performance of all BNR systems can hinge on solids treatment processes. Anaerobic digestion results in phosphorus release from the PAOs, as well as high ammonia concentrations. These loads can reduce the performance of the BNR process if not treated separately, either chemically or biologically, prior to recycle to the activated sludge system. Aerobic digestion represents the basis of this evaluation. Aerobic digestion is more cost-effective than anaerobic digestion at this size (generally true for wastewater facilities smaller than approximately 5 MGD), but it is also more energy-intensive. The retainage of most of the phosphorus removed in the BNR process is an added benefit to aerobic digestion.

7.1.6.2.2 Basic Equipment List

- Headworks Facility:
  - Mechanical Perforated Screens
  - Washer Compactor
  - Grit Removal Equipment
  - Influent Flow Sampler
- 5-Stage Bardenpho (Alternative T-5B):
  - Air Compressors (Blowers)
  - Air Diffusers
  - Submersible Mixers
  - Internal Recycle Pumps
  - Instrumentation & Controls.
  - Chemical Feed
  - Clarifier Equipment
- Tertiary Filtration
  - Cloth Filtration Equipment
  - Coagulant Feed Pumps
- UV Disinfection Facility:
  - UV Lamps and Banks
  - Effluent Flow Sampler
- Digestion & Biosolids:
  - Mechanical Thickening Unit
  - Digester Feed Pumps
  - Polymer Feed Pumps
  - Air Compressors (Blowers)

- Jet Aeration Headers
- Aerobic Digester Mixing Pump
- Digested Sludge Transfer Pumps
- Sludge Dewatering Equipment (Screw Press)

7.1.6.2.2 Cost Estimate

Table 7-12 summarizes estimated capital costs for Alternative T-5B.

Table 7-12
Alternative T-5B: Greenfield 5-Stage Bardenpho Facility
Engineer's Opinion of Probable Construction Cost

Construction Costs		
General Conditions		
Bonding / Insurance / Project Mgmt & Admin. / Mobilization		$1,955,400
Site Work		
Land Acquisition	$500,000	
Site Management / SWPPP	$79,700	
Headworks	$12,600	
Control Building	$0	
Bardenpho & Clarifiers	$471,600	
UV Disinfection	$11,000	
Digestion & Biosolids	$53,900	
Site Improvements - (Grading & Site Piping)	$247,095	
SUBTOTAL: SITE WORK		$1,375,900
Structural & Architectural		
Headworks	$544,000	
Control Building	$1,561,428	
Bardenpho & Clarifiers	$4,643,000	
UV Disinfection	$274,000	
Digestion & Biosolids	$1,867,000	
SUBTOTAL: STRUCTURAL & ARCHITECTURAL		$8,889,400
Process Equipment & Piping		
Headworks	$712,238	
Control Building	$1,023,900	
Bardenpho & Clarifiers	$1,988,835	
UV Disinfection	$211,855	
Digestion & Biosolids	$5,234,000	
Cloth Filtration (P-Removal)	$643,000	
Installation & Start-Up	$2,944,100	
SUBTOTAL: EQUIPMENT & FURNISHINGS		$12,757,900

Table 7-12 (Cont) Alternative T-5B: Greenfield 5-Stage Bardenpho Facility Alternative T-5B: Greenfield 5-Stage Bardenpho Facility		
Mechanical		
Headworks	$14,300	
Control Building	$10,530	
Bardenpho & Clarifiers	$0	
UV Disinfection	$9,500	
Digestion & Biosolids	$26,300	
Installation & Start-Up	$9,095	
SUBTOTAL: MECHANICAL		$69,700
Electrical		
Electrical / Instrumentation & Controls		$4,841,000
SUBTOTAL		**$29,889,300**
Undeveloped Design Details	10%	*$2,988,900*
Construction Contingencies	15%	*$4,483,400*
SUBTOTAL: ESTIMATED CONSTRUCTION COST		**$37,361,600**
NON-CONSTRUCTION COSTS		
SUBTOTAL: Administrative / Engineering / & Legal		**$9,341,000**
TOTAL ESTIMATED PROJECT COST		**$46,702,600**

7.1.6.3 Alternative T-5C: Membrane Bioreactors (MBR)

The final categorization of mechanical treatment evaluated for a greenfield facility is similar to regular BNR, except, in this example, membranes separate solids from the waste effluent as opposed to relying upon settling equipment and clarifiers for natural or gravity separation of solids. Phosphorus removal is achieved by relying upon P-uptake from the PAOs. As long as the membranes remain submerged in an aerobic environment, the PAOs in the solids will retain the phosphorus within the mass of the microorganisms, preventing phosphorus from moving across the membrane with the effluent. WAS pumps waste PAO's to the solids waste stream along with the phosphorus they contain. Once the solids waste stream become anaerobic the PAO's release their phosphorus in favor of acetate due to the absence of oxygen required for the synthesis of orthophosphate. For the purposes of this evaluation, membrane bioreactor (MBR) treatment is deemed representative of a facility that would achieve limits of 6.0 / 0.3 mg/L (TN/TP) reliably.

MBRs use membranes for advanced wastewater treatment. The suspended growth activated sludge process is similar, as the waste stream goes through nitrification and denitrification for removal of ammonia-N and nitrate-N. However, the membranes preclude the need for tertiary treatment as they provide the means to separate the solids from the liquid waste streams. MBR plants often require a smaller footprint and produce effluents with lower nutrient concentrations. The operating cost and energy consumption

is also typically much higher than other processes due to the aeration requirements and energy required to pump effluent through the membranes with high head losses. Figure 7-11 shows a typical process flow diagram for a standard MBR process.

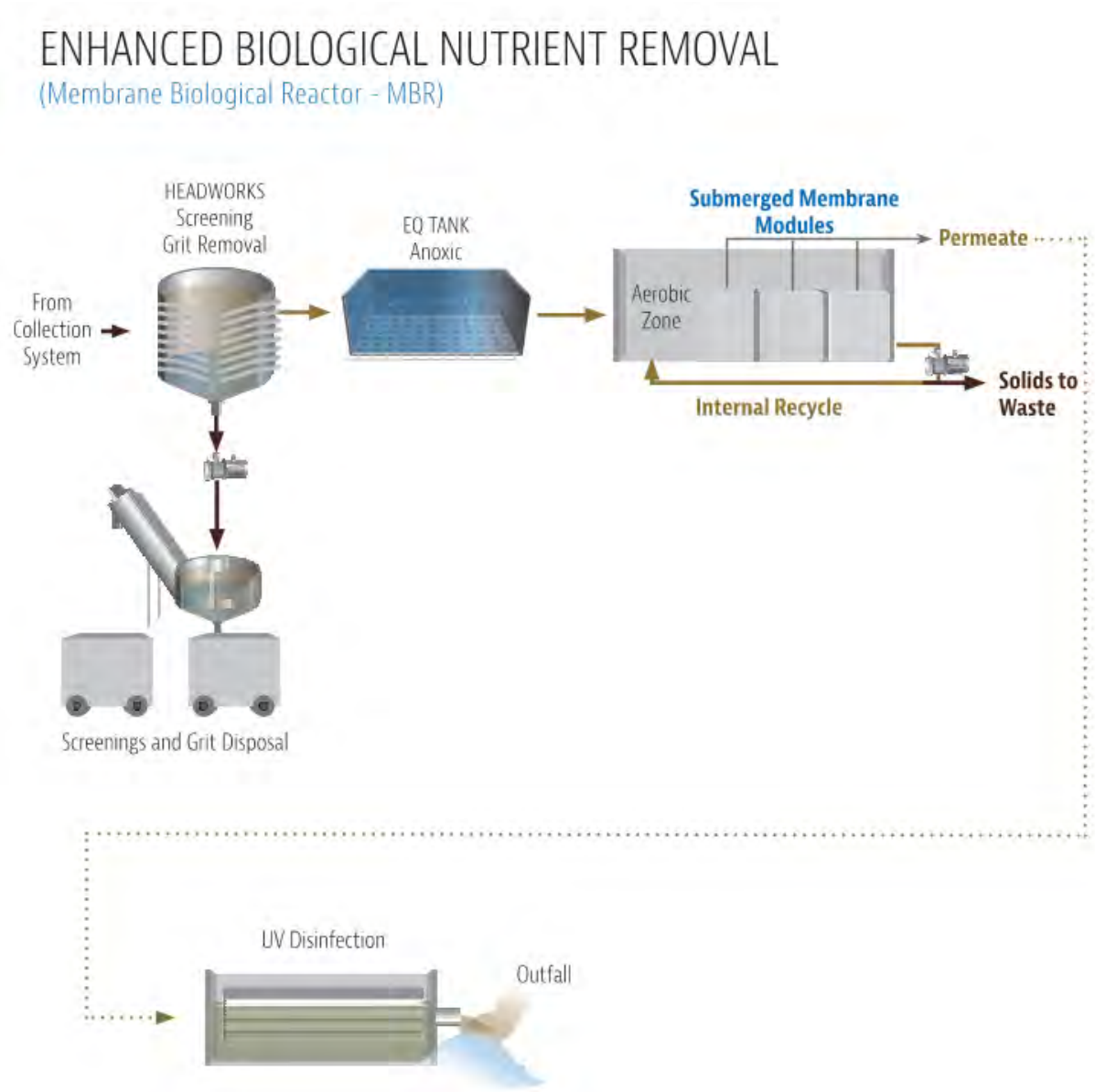


Figure 7-11: Alternative T-5C: Membrane Bioreactor (MBR)

7.1.6.3.1 Basic Equipment List

- Headworks Facility:
  - Mechanical Perforated Screens
  - Washer Compactor
  - Grit Removal Equipment
  - Influent Flow Sampler
- MBR (Alternative T-5C):

- Membrane Equipment
- Permeate Pumping
- Back pulse System
- Membrane Air-Scour
- RAS Pumps
- Membrane Cleaning Equipment
- Chemical Feed Skid
- Air Compressors (Blowers)
- Instrumentation & Controls
- Bridge Crane

- UV Disinfection Facility:
  - UV Lamps and Banks
  - Effluent Flow Sampler
- Digestion & Biosolids:
  - Mechanical Thickening Unit
  - Digester Feed Pumps
  - Polymer Feed Pumps
  - Air Compressors (Blowers)
  - Jet Aeration Headers
  - Aerobic Digester Mixing Pump
  - Digested Sludge Transfer Pumps
  - Sludge Dewatering Equipment (Screw Press)

7.1.6.3.2 Cost Estimate

Table 7-13 provides the estimated capital costs for Alternative T-5C.

Table 7-13
Alternative T-5C: Greenfield MBR Facility
Capital Costs

CONSTRUCTION COSTS		
General Conditions		
Bonding / Insurance / Project Mgmt & Admin. / Mobilization		$2,090,600
Site Work		
Land Acquisition	$400,000	
Site Management / SWPPP	$79,200	
Headworks	$12,600	
Control Building	$0	
MBR	$468,300	
UV Disinfection	$11,000	
Digestion & Biosolids	$53,900	
Site Improvements - (Grading & Site Piping)	$245,610	
SUBTOTAL: SITE WORK		$1,270,600

Table 7-13 (Cont.) Alternative T-5C: Greenfield MBR Facility Capital Costs		
Structural & Architectural		
Headworks	$544,000	
Control Building	$1,334,000	
MBR	$3,981,000	
UV Disinfection	$274,000	
Digestion & Biosolids	$1,867,000	
SUBTOTAL: STRUCTURAL & ARCHITECTURAL		$8,000,000
Process Equipment & Piping		
Headworks	$712,238	
Control Building	$1,023,900	
MBR	$3,889,800	
UV Disinfection	$238,337	
Digestion & Biosolids	$5,234,000	
Installation & Start-Up	$3,329,500	
SUBTOTAL: EQUIPMENT & FURNISHINGS		$14,427,800
Mechanical		
Headworks	$14,300	
Control Building	$9,000	
MBR	$144,100	
UV Disinfection	$9,500	
Digestion & Biosolids	$26,300	
Installation & Start-Up	$30,480	
SUBTOTAL: MECHANICAL		$233,700
Electrical		
Electrical / Instrumentation & Controls		$5,933,200
SUBTOTAL		**$31,955,900**
Undeveloped Design Details	10%	*$3,195,600*
Construction Contingencies	15%	*$4,793,400*
SUBTOTAL: ESTIMATED CONSTRUCTION COST		**$39,944,900**
NON-CONSTRUCTION COSTS		
SUBTOTAL: ADMINISTRATIVE / ENGINEERING / & LEGAL		$9,987,000
Total Estimated Project Cost		**$49,931,900**

7.1.6.3.3 Maps

Preliminary site layout plans are not included for Alternative T-5: Greenfield Facilities. If a greenfield facility was desired, further planning would be required to identify and procure the exact parcel of land to develop as a greenfield wastewater treatment facility.

7.1.6.3.4 Biosolids Considerations

Mechanical water resource recovery facilities produce a solids waste stream that lagoon facilities typically do not require. If storage of biosolids onsite in a facultative lagoon is not possible, biosolids would require further mechanical stabilization (digestion) prior to disposal. Digestion if completed to reduce the bacteriological hazard otherwise imposed by the presence of pathogens. The Code of Federal Regulations regulates Biosolids management (40 CFR Part 503). Facilities treating domestic sewage must apply for and maintain a permit covering biosolids use or disposal. The two primary categories of biosolids digestion include aerobic and anaerobic digestion.

7.1.6.3.5 Anaerobic Digestion

Anaerobic digestion does not require additional air compressor capacity but does require the digesters be heated to maintain operations. As a benefit, anaerobic digestion allows for the capture and beneficial reuse of volatile gasses that are released by the stabilization process. However, anaerobic digestion is typically not feasible for facilities running less than 5.0 MGD and extra precaution is required when working around the gasses that are produced in an anaerobic digester.

7.1.6.3.6 Aerobic Digestion

Because the City of Belgrade's waste facility is not expected to exceed 5.0 MGD, the recommended digestion process would be aerobic digestion. Aerobic digestion simply creates aerobic conditions to achieve the desired stabilization in the digester tanks through nitrification and denitrification. Air compressors and aeration diffusers assist in achieving the aerobic conditions in the digesters and supplementary heat is not typically required. Operational considerations for aerobic digestion include monitoring waste sludge characteristics, oxygen requirements, pH, temperature, mixing, and solids retention time (SRT). Figure 7-12 shows the typical PFD for operating the aerobic digestion facility.

Figure 7-12: Aerobic Digestion PFD

The major components in the process generally include the follow:

1. WAS Storage:
   a. Typically, an aerated storage basin intended to serve as a reservoir for Waste Activated Sludge (WAS).
   b. WAS removed from the secondary treatment process is held in WAS storage.
   c. WAS storage is ideally sized adequately for 3 to 5 days of WAS storage capacity.
2. Thickening:
   a. Pre-digestion thickening removes water from the WAS and therefore, reduces the volume of tank capacity required for aerobic digestion.
   b. Polymer addition optimizes the thickening.
   c. Pre-Thickener: WAS Solids Content = 0.75 - 0.90 %-solids.
   d. Post-Thickener: WAS Solids Content = 3.0 – 3.5 %-solids.
3. Aerobic Digestion
4. Dewatering
   a. Post-digester solids dewatering reducing weight and volume to reduce disposal costs.
   b. Polymer addition optimizes the dewatering process.
   c. Pre-dewatering: Digested Sludge Solids Content = 3.0 – 3.5 %-solids
   d. Post-dewatering: Digested Sludge Solids Content = 16 – 25 %-solids.
   e. 16 %-solids is considered the lower limit if solids content for hauling. At these solids contents, sludge will pass the “paint-filter test” and does not drip water.

7.1.6.3.7 Sludge Volumes and Disposal Costs

Volumes of sludge produced for the City of Belgrade were estimated based on flows and loads analysis and assumptions on calculable parameters typically seen in similar aerobic digestion facilities. The volume of solids produces is considerable and therefore disposal and handling fees are commonly associated. Table 7-14 summarizes assumed sludge production parameters; Table 7-15 reports estimated sludge production volumes for the three greenfield sub-alternatives.

Table 7-14 Assumed Parameters for Sludge Production		
Parameter	**Units**	**Aerobic Digestion Alternatives**
Design Assumptions		
Waste Activated Sludge		
Sludge Yield	[lb VSS / lb BOD]	0.90
Preliminary Treatment BOD Removal	[%]	0
Volatile Solids Fraction	[-]	0.67
Percent Solids	[%]	0.75
Thickening		
Discharge Percent Solids	[%]	3.50
Percent Capture	[%]	95
Aerobic Digestion		
Percent Solids	[%]	3.50
Volatile Solids Reduction	[%]	30
Dewatering		
Discharge Percent Solids	[%]	20
Percent Capture	[%]	95

Table 7-15 Sludge Production Volumes for SBR, 5-Stage Bardenpho, and MBR, Respectively				
Parameter	**Units**	**Alternative**		
		SBR	**5-Stage Bardenpho**	**MBR**
Population	[PE]	19,360	19,360	19,360
Basis of Design Values				
Influent BOD Loading				
Average Annual	[ppd]	5,678	5,678	5,678
Peak Month	[ppd]	8,161	8,161	8,161
Sludge Production				
Average Annual	[ppd]	5,110	5,110	5,110
	[gpd]	81,698	73,823	68,082
Peak Month	[ppd]	7,345	7,345	7,345
	[gpd]	117,424	106,106	97,854
Thickening Discharge				
Average Annual	[ppd]	4,855	4,855	4,855
	[gpd]	16,631	16,631	16,631
Peak Month	[ppd]	6,978	6,978	6,978
	[gpd]	23,904	23,904	23,904
Aerobic Digestion Discharge				
Average Annual	[ppd]	3,879	3,879	3,879
	[gpd]	13,288	13,288	13,288
Peak Month	[ppd]	5,575	5,575	5,575
	[gpd]	19,100	19,100	19,100
Dewatering Discharge				
Average Annual	[ppd]	3,703	3,703	3,703
	[gpd]	2,220	2,220	2,220
Peak Month	[ppd]	5,322	5,322	5,322
	[gpd]	3,191	3,191	3,191
Volumetric Cake Discharge				
Average Annual	[ft^3/day]	292	292	292
	[CY/day]	10.8	10.8	10.8
Peak Month	[ft^3/day]	420	420	420
	[CY/day]	15.6	15.6	15.6

Common operations and disposal requirements include hauling biosolids to a facility for beneficial reuse. Landfills are one candidate of a facility with a beneficial reuse for biosolids: daily cover for the landfill operations. It is assumed that the City of Belgrade would haul biosolids to the Logan Landfill for disposal. Hauling and disposal costs for solids are assumed for. Quantities and costs were calculated for all three secondary treatment alternatives, but due to the equality in assumed solids content after the thickening equipment, differences in

production quantities and subsequent hauling costs were not identified. The hauling costs assume a 42-mile round-trip to the Logan Landfill. Table 7-16 summarizes these biosolids hauling and disposal costs.

Table 7-16 Alternative T-5: Greenfield Mechanical Treatment Annual Disposal Costs for Mechanical Solids Digestion	
Average Annual Cake Solids	
Cubic Yards:	3,942
Tons:	3,371
Hauling Costs:	
Hauling Distance (Roundtrip):	42 (Logan Landfill)
Dump Truck Capacity (CY):	12
Dump Truck Capacity (tons):	10
Trips per Week:	7
Cost per Trip (No Labor; Truck O&M):	$25
Hauling Cost per Year:	$9,100
Disposal Costs:	
Landfill Tipping Fee ($/Ton):	$50
Landfill Tipping Cost per Year:	$168,528.00
Total Annual Biosolids Disposal Cost per Year:	**$177,628.00**

7.1.6.3.8 Treatment During Construction

If the City were to proceed with construction of a mechanical water resource recovery facility, impacts to the existing lagoon process would be minimal. The City could continue operating and maintaining the lagoon system during construction of a mechanical treatment facility as long as the new facility is designed with a footprint small enough to fit on the existing site without impacts to existing lagoons or is located at an entirely new site. The planning team anticipates the following minimal level of coordination during and shortly after construction:

- Utility Connections and Extensions
  - Collection system tie-in
  - Potable distribution extensions.
- Supply of potable water upon initial start-up of equipment
- Coordination to make final tie-in to the new mechanical treatment system upon substantial completion and full commissioning of the mechanical plant.
- Pumping the liquid contents of the City's lagoon system to the mechanical plant for blending with influent, and subsequent treatment and discharge.
- Dewatering and drying biosolids left in the lagoons.
- Infill and decommission of the existing lagoons if surface water discharge is desired.

This all assumes that the existing lagoons would not be utilized for any equalization or biosolids treatment after a move to mechanical treatment. This

should be reviewed with a more detailed Facility Plan if mechanical treatment becomes an imminent path forward for the City.

7.1.6.3.9 Operations and Maintenance

Due to the complexity and significantly large investment in planning for a greenfield treatment facility, O&M costs are projected at a conceptual level. A more in-depth evaluation of a particular process's actual O&M costs and electrical load requirements should be considered in finer detail. Table 7-17 summarizes those conceptual level costs. No further validation for exact electrical loadings is provided and chemical coagulant costs are also left as conceptual as validation would require pilot scale performance testing to identify polymer application rates specific to the Belgrade plant.

Table 7-17
Alternative T-5: Greenfield Treatment Facilities
Annual O&M Budget Projection

Cost	T-5A: SBR	T-5B: Bardenpho	T-5C: MBR
Staffing & Labor	$420,000	$420,000	$420,000
Equipment O&M	$469,000	$525,560	$560,000
Utilities:	$275,650	$317,000	$365,550
Chemical Coagulants:	$0.00	$120,000	$0.00
Annual Total:	**$1,164,650**	**$1,342,560**	**$1,353,550**
Real Interest Rate = 0.20%			
20 Year NPV	**$22,811,000**	**$26,295,000**	**$26,510,000**

7.1.6.3.10 Staffing Requirements

A mechanical treatment facility requires maintenance by licensed operators. Currently there is a shortage of licensed operators experienced with mechanical treatment plant operation and nutrient removal, and competition for the labor force that does exist is significant. If the City moves to mechanical treatment, it should consider early training and development of the City's current staff of operators to the extent feasible.

A robust O&M is critical for successful performance of a mechanical plant. More attention must be given to operating parameters when nutrient removal is required. Prioritizing O&M of major equipment at a mechanical facility avoids critical failures and extends the useful life of the facility's assets. Asset management approaches to O&M have become standard practice and include equipment cataloging, maintenance scheduling and tracking, and risk-based prioritization of long-term equipment rehabilitation and replacement.

The Northeast Guide for Estimating Staffing at Public and Privately Owned Wastewater Treatment Plants (Guide) provides in depth considerations for facilities when considering staffing requirements. Generally, this guide outlines five basic categories of operational tasks for staffing needs: (1) Basic and Advanced Operations and Processes; (2) Maintenance; (3) Laboratory Operations; (4) Biosolids/Sludge Handling; and (5) Yardwork / Grounds Maintenance. The Guide also recommends additional staffing considerations for managerial, human resources, and related administrative office tasks.

The Engineer referenced this guide when considering the operational requirements, the City of Belgrade would need with a mechanical treatment plant. Based on this review, and a comparison of similarly sized facilities, this evaluation document recommends planning around the FTE needs summarized in Table 7-18, below, for each secondary treatment process, respectively.

Table 7-18
Summary of Operations and Maintenance Staffing Recommendations-Relative to Facility Treatment

Operations and Maintenance Task	Annual Hours		
	SBR	**BARDENPHO**	**MBR**
1 - Basic Advanced Operations and Processes	3,712	4,032	3,552
2 - Maintenance	2,218	2,842	2,762
3 - Laboratory Operations	586	586	586
4 - Biosolids / Sludge Handling	1,600	1,600	1,600
5 - Yardwork	625	625	625
Estimated Operations & Maintenance Hours	**8,741**	**9,685**	**9,125**
Annual Hours / FTE	1,500	1,500	1,500
Estimated Operations & Maintenance Staff	5.90	6.50	6.10
Total FTE Recommendation	**6.00**	**7.00**	**6.00**

Notes on Staffing Recommendations:

- Annual Hours / FTE assumes operators are 72% efficient –
  - 6.5 hours of productivity per day
  - Accounts for vacation time and Holiday leave.
- No Additional staffing added for Managerial and Admin Requirements.
  - The requirements of this position are typically included in the job description of the lead operator or plant superintendent.
  - The City of Belgrade will presumably handle Human Resources tasks and other Administrative roles through existing departments.
- Overlap (existing or potential) should be considered when evaluating staffing requirements.
  - Some operators may be cross-trained in both mechanical treatment and collection system maintenance.

7.2 Disposal Alternatives

Alternatives involving upgrades and expansion to the City's existing disposal methods are discussed in the sections to follow.

7.2.1 Available Storage

The various treatment options discussed in Section 7.1 offer varying available storage volumes. In Alternatives T-4A(1) and T-4B, only Lagoon #3 is available for storage, Alternative T-4A(2) includes Lagoons #2 and #3 as storage lagoons and all three existing lagoons are available for storage in Alternative T-5. Lagoons #1 and #2 have an operating capacity of 16 MG; Lagoon #3 has an operating capacity of 81.5 MG. This information is summarized in Table 7-19.

Table 7-19
Available Storage

Alternative	Total Available Storage (MG)
T-4A(1)	81.5
T-4A(2)	97.5
T-4B	81.5
T-5	113.5

7.2.2 Alternative D-1: No Action

This alternative involves allowing the City's current disposal system to remain intact. As discussed in Chapter 5, the hydraulic capacity of each IP bed is roughly 1,500,000 gpd. With DEQ's recommended wetting/drying ratio, the allowable average day discharge is 589,000 gpd per bed in the summer months and 362,000 gpd per bed in the winter months. These flow rates will maintain average monthly TN loading below current permit limitations with the design TN effluent concentration of 13.5 mg/l. An evaluation of the existing plumbing indicates the existing pipes and pumps can deliver more treated wastewater to the IP beds then the beds themselves can discharge. As such, the hydraulic capacity of the beds was referenced for the existing allowable outflow.

Design agronomic rates were calculated in Chapter 5, assuming 13.5 mg/l of TN in the effluent. Average day flow rates to the spray irrigation system from May to September were calculated based on design agronomic rates. Flow rates were then modified to maintain pump run times less than or equal to 12 hr/day, based on the nominal capacity of the existing irrigation pump.

A month-by-month water balance was calculated to predict the available disposal capacity of the existing system. The estimated allowable flow to the IP beds and irrigation system were referenced along with lake evaporation data from the Bozeman-Yellowstone International Airport's weather station as outflows. Site specific precipitation data with estimated average day influent rates were referenced to determine total lagoon inflows. It was estimated that an average daily influent flow rate of 1.38 MGD would cause the accumulated storage to be 0.0 gallons at the end of the irrigation season. This would require a total available storage of at least 56.4 MG. The required storage volume is less than the storage provided by the existing system.

Based on flow projections previously discussed, the City's average day wastewater flow rate will exceed 1.38 MGD in the year 2032. To provide a 10% safety factor, it is suggested that the City consider upgrading the disposal system in 2029. It should be noted that mechanical failure resulting in replacement of the existing pumps is possible prior to 2032. Detailed calculations and the month-by-month water balance are available in Appendix 7.

7.2.3 Alternative D-2: Disinfection and Surface Water Discharge

This alternative involves discharging treated wastewater to nearby surface water. Should the City elect to pursue treatment Alternative T-5, surface water discharge would also be available as a final disposal alternative. However, replacing the current disposal method is not recommended considering groundwater disposal and spray irrigation infrastructure currently owned by the City operate well and are in good condition. Additionally, the City would have to obtain a surface water discharge permit from the DEQ's Permitting and Compliance Division. Pollutant limitations would likely increase as a result of Alternative D-2. Without exhaustive analysis and lengthy negotiations with DEQ, these limits are difficult to predict; however, ammonia and total phosphorous limitations are common. Because of the added capital cost associated with required infrastructure and the anticipated obstacles associated with a new surface water discharge permit, Alternative D-2 is not considered a feasible disposal option and, as such, has been eliminated from further consideration.

7.2.4 Alternative D-3: Additional IP Bed

7.2.4.1 Description

Alternative D-3 includes the construction of a fourth IP bed, identified as IP Bed D. This bed would be constructed in the same manner as the existing beds. IP Bed D would consist of 5 infiltration cells, linearly connected and running east to west. Each cell would be roughly 100 ft by 200 ft providing approximately 20,000 SF of infiltration area per cell, or 100,000 SF total. A 12-inch PVC pipe would be included as a header pipe with ten 8-inch laterals branching off into the infiltration cells. A schematic of the typical IP Bed configuration was provided earlier in Figure 4-6.

This alternative also includes additional piping to transport the treated effluent to IP Bed D. The existing pump IP-2 transports treated wastewater to IP Bed C and it is recommended the pump be utilized convey treated effluent to the proposed IP Bed D. A 12-inch transmission main will be constructed. Finally, new monitoring wells will need to be drilled within the mixing zone to allow for groundwater testing.

This alternative also includes automated controls within the IP bed system. As a result, treated effluent can be directed to the four IP Beds automatically. Manual controls would no longer be required, ultimately reducing O&M practices.

The capacity of the forth IP bed will render the spray irrigation system unnecessary. However, non-discharging disposal methods including land application though spray irrigation, have a number of environmental benefits. As such, it is recommended the City of Belgrade maintain their existing irrigation system. This will provide flexibility within their disposal options and service the City well past the 20-year design life proposed by this Master Plan.

7.2.4.2 Design Criteria

Circular DEQ-2, Section 122 provides design standards for IP beds. All standards discussed within the Circular have been considered in the preliminary design of Alternative D-3. These standards include, but are not limited to:

- IP bed must not be located within a 100-year flood plain
- IP bed must be located at least 500 feet from any water supply wells
- Soil in the area must have a permeability greater than or equal to 0.6 in/hr
- Application rates are to be calculated based on 7 to 10% of the soils permeability and with wetting drying ratios specified in Table 122-2 of Circular 2.
- Bed construction shall include side slopes no steeper than 3:1, overflow piping, uniform grading and fences to discourage unauthorized entry.

Additionally, the new outfall will be considered a new or increased source of groundwater contamination by the DEQ and trigger the State's non-degradation policy. All viable treatment alternatives discussed previously will produce a treatment system classification of Level 2 in ARM 17.30.702(11). This results in a 7.5 mg/l allowable groundwater nitrate concentration at the end of the mixing zone as specified in both 75-5-301(5)(d)(iii), MCA and ARM 17.30.715(1)(d)(ii). A non-degradation analysis assuming similar mixing zone characteristics of the current IP Beds was performed and is available in Appendix 7. It was estimated that an average day discharge to IP Bed D of 316,664 gpd would result in a nitrate concentration of 6.75 mg/l at the end of the mixing zone and provide a 10% safety factor for groundwater nitrate concentrations.

A month-by-month water balance was utilized to evaluate Alternative D-3. The Bozeman-Yellowstone International Airport's weather station data was referenced for precipitation and evaporation data. At the design average day flow rate of 1.67 MGD an average day discharge rate of 223,639 gpd to IP Bed D will result in a cumulative storage of 0.0 gallons in the storage lagoon at the end of September and a maximum cumulative storage of 68.1 MG in March. This is assuming maximum allowable discharge rates to Beds A, B and C, as calculated in Chapter 5. The average day discharge rate to IP Bed D is less than the estimated hydraulic capacity of the IP beds and the allowable discharge rate estimated by the State's non-degradation analysis. The required storage is less than available storage for all viable treatment options. The water balance was calculated assuming no discharge to the irrigation system took place and all four IP Beds received treated effluent year-round.

It is suggested to utilize the existing pump IP-2 to transport treated wastewater to IP Bed D. The nominal capacity of the existing pump is 1,400 gpm. To supply a discharge rate of 223,639 gpd to IP Bed D, the average day pump run time of pump IP-2 would increase by approximately 2.7 hr/day.

7.2.4.3 Map

Two possible locations are proposed for IP Bed D. Location 1 is north west of the existing lagoons, adjacent to IP Bed B; location 2 is south east of the ponds, adjacent to IP Bed C. Both locations provide the possibility to tie into existing transmission mains. Four spray irrigation laterals must be removed to provide sufficient space at location 2. This will decrease the disposal capacity of the irrigation system, however as previously

discussed, four IP beds will provide enough disposal capacity to sustain the City beyond the 20-year design life and the irrigation system will not be strictly necessary. Location 2 is also up gradient of the existing lagoons and IP Beds A and B. Issues associated with cumulative nitrogen groundwater concentrations may arise as a result. Both locations are owned by the Gallatin Airport Authority.

The two disposal sites are illustrated in Figure 7-13.

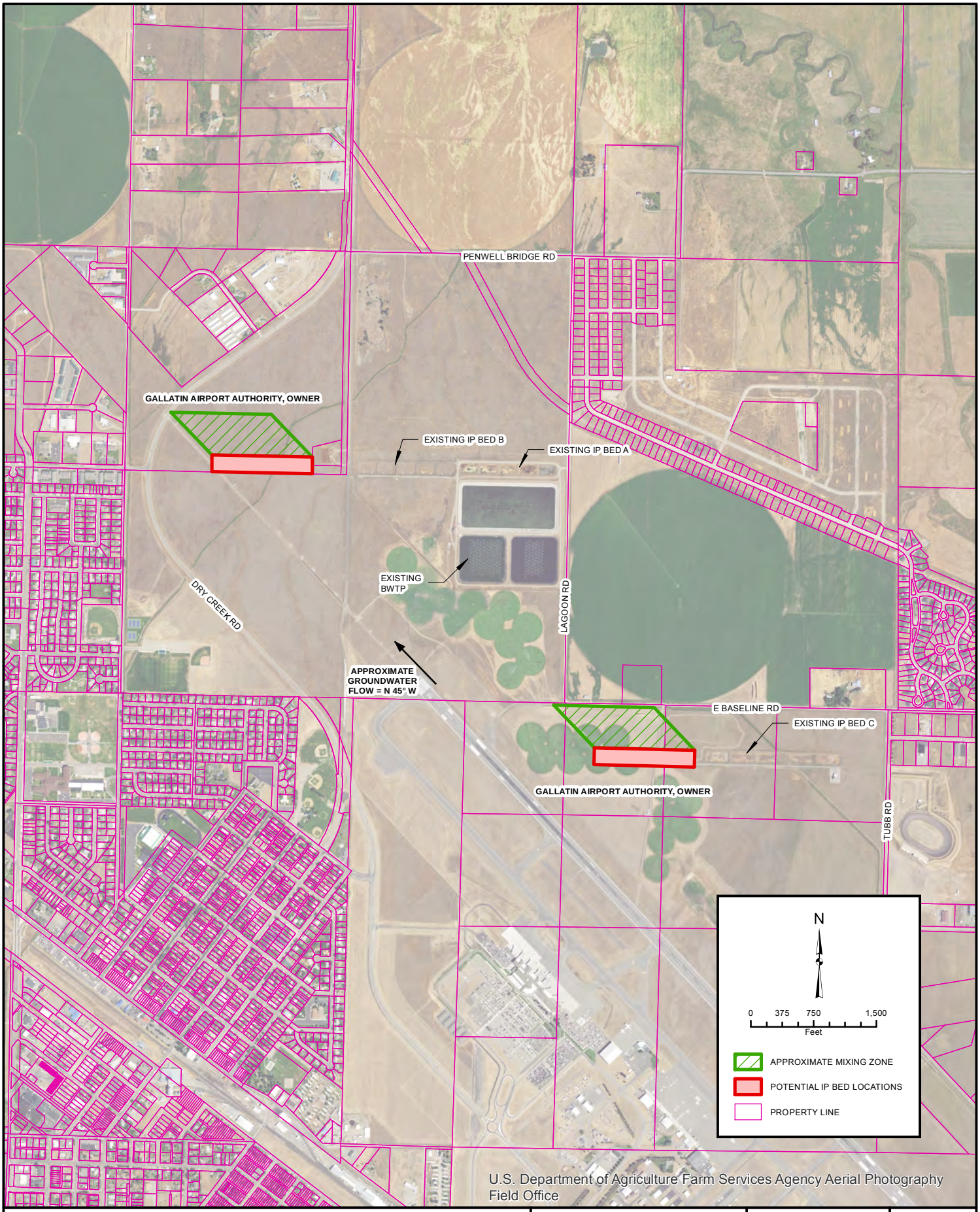
7.2.4.4 Treatment During Construction

Major disruptions to the City's wastewater treatment system are not anticipated as a result of constructing Alternative D-3. The treatment system could operate as designed. Additionally, the efficiency of the existing disposal method would not be consequentially impacted during IP Bed D construction.

7.2.4.5 Operations and Maintenance

No significant changes to the current O&M procedures are expected to result from Alternative D-3. The addition of automatic controls will decrease the labor required to direct treated effluent to IP Beds for disposal. No additional staffing will be required for this alternative. Increases in annual O&M cost are expected to result from the additional pumping required to dispose of the treated wastewater. The existing pumps IP-1 and IP-2 each have nominal capacities of 1,400 gpm. Estimated run times for pump IP-1 are 14.0 hr/day in the summer months and 8.6 hr/day during winter months to provide average day flows or 589,129 gpd and 362,541 gpd to Beds A and B in the summer and winter, respectively. Pump IP-2 will transport effluent to IP Beds C and D for disposal. IP Bed C can dispose of approximately 589,129 gpd in the summer and 362,541 gpd in the winter. IP Bed D will be required to dispose of 223,639 gpd year-round. This equates to average pump run times for pump IP-2 of approximately 9.7 hr/day in the summer and 7.0 hr/day in the winter.

Assuming an electricity cost of $0.10 per kW-hr and 40 HP motors on each pump, **the annual utilities cost of the two IP pumps is estimated at $21,400.** Energy consumption estimates are provided in Appendix 7.



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BELGRADE WASTEWATER MASTER PLAN

BELGRADE, MT

ALTERNATIVE D-3: ADDITIONAL IP BED

POTENTIAL IP BED D LOCATIONS

TD&H Engineering

406.761.3010 • tdhengineering.com

1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY:	CJS
DESIGNED BY:	
QUALITY CHECK:	
DATE:	05/31/2017
JOB NO.:	B16-048
CADD NO.:	B16-048 Fig 7-X.MXD

FIGURE

7-13

7.2.4.6 Cost Estimate

Planning level capital costs for the construction of IP Bed D are presented in Table 7-20. The capital cost estimate includes activities anticipated for the successful installation of IP Bed D. New infrastructure includes, but is not limited to, new 12-inch transmission main, automatic controls and monitoring well installation. To ensure a conservative estimate, the total construction costs for Alternative D-3 also includes a 15% contingency, and 25% for engineering, legal and administrative fees. **The estimated total construction cost for Alternative D-3 is $620,000**

Table 7-20
Alternative D-3
Construction Cost Estimate

Description	Quantity	Unit	Unit Cost	Total Cost
Mobilization	5	%		$20,528
New 12-inch Transmission Main	1	EA	$80,000	$80,000
New 8-inch Laterals	10	EA	$4,000	$40,000
Excavation and Embankment	19,000	CY	$6	$114,000
Automatic Controls	1	LS	$100,000	$100,000
Overflow Piping	4	EA	$1,500	$6,000
Monitoring Wells	3	EA	$15,000	$45,000
Layout and Construction Staking	1	LS	$7,500	$7,500
Miscellaneous Fieldwork or Materials	10,000	Units	$1	$10,000
Construction Materials Testing	2	%		$8,050
			Subtotal	**$431,078**
		Contingency	15%	$64,662
			Total Construction Estimate	**$495,739**
		Administrative, Engineering and Legal	25%	$123,935
			Estimated Total Cost (rounded to the nearest thousand)	**$620,000**

7.2.5 Alternative D-4: Spray Irrigation System Upgrades

7.2.5.1 Description

Alternative D-4 involves upgrading the existing spray irrigation system. Upgrades to the system would include an upsized irrigation pump to supply the design agronomic rates discussed in Chapter 5, new sprinkler heads and expansion of the treatment plant's existing storage. The existing irrigation system contains 52 sprinkler heads, each with a 200-foot application radius. The total application area is 117 acres. The size and general layout of the existing system will be maintained in this alternative.

7.2.5.2 Design Criteria

7.2.5.2.1 State Regulations

Circular DEQ-2 outlines criteria for land application through spray irrigation. Table 7-21 summarizes the criteria for irrigation pond sizing and location.

Table 7-21
Wastewater Treatment Standards for Irrigation

Circular DEQ-2 Criteria	Parameter
Emergency or Winter Storage [(1)]	60-120 days
Minimum Buffer Zone for Irrigation (No Disinfection)	200 feet
Minimum Buffer Zone for Irrigation (Disinfection)	50 feet
Minimum Setback from Buffer Zone to Well	50 feet

[(1)] Emergency or winter storage volume is generally governed by the month-by-month water balance regardless or primary/secondary treatment.

7.2.5.2.2 Disposal Rates

A month-by-month water balance at design conditions was prepared for preliminary analysis of Alternative D-4. This water balance assumes the design average day flow rate of 1.67 MGD along with site specific precipitation data as lagoon inflow. Lake evaporation data collected from the airport was referenced with flow rates to existing IP Beds and design agronomic rates as effluent flows. It is estimated that applying 100% of the allowable flow rate to the IP Beds, will require the irrigation system to operate at 73% capacity for the accumulated storage to equal 0.0 gallons at the end of the irrigation season. The detailed water balance is available in Appendix 7.

7.2.5.2.3 Required Seasonal Storage

The month-by-month water balance was also used to evaluate seasonal storage needs. It was found that the maximum storage volume required is approximately 108.9 MG. This equates to 65.2 days of detention time at design average day flow rates. Additional storage will be required with Alternative T-4. Alternative T-5 has an estimated available storage of 113.5 MG, and would therefore not require additional storage.

Option T-4A(1) and T-4B provide the least storage volume at 81.5 MG; Alternative T-4A(2) offers 97.5 MG of storage. An additional 27.4 MG of storage will be required with Alternative T-4A(1) and T-4B, and 11.4 MG of storage will be required for Alternative T-4A(2).

Lagoon #3 is the only available basin for seasonal storage associated with treatment options T-4A(1) and T-4B. In order to expand Lagoon #3 by 27.4 MG, major modifications would be required. The bottom of the basin would be lowered, causing major damage to the existing liner. As a result, a complete liner replacement of 15.8 acres would be necessary. Additionally, the maximum water surface elevation and surrounding embankment would have to increase

substantially. Significant alterations to the berms and interpond piping would be necessary to provide sufficient space for the required air header piping and maintain access to all areas of the treatment plant. Considering the significant cost necessary to increase storage by 27.4 MG in Lagoon #3, it is not recommended to combine disposal Alternative D-4 with treatment Alternatives T-4A(1) and T-4B.

In order to incorporate disposal Alternative D-4 with treatment Alternative T-4A(2), an additional 11.4 MG of storage is required. Lagoons #2 and #3 are available for storage in T-4B. To prevent the need for complete liner replacement, neither basin bottom will not be lowered. Rather, it is recommended to raise the maximum water surface elevation of Lagoon #2 by 4.35 feet; from an elevation of 4410.9 feet to 4415.25 feet. Additionally, the sludge accumulation allowance at the bottom of Lagoons #2 and #3 will be eliminated. A vast majority of sludge is expected to be removed in the treatment lagoon and nitrification and denitrification reactors. This results in an operating capacity in Lagoon #2 of 27.9 MG and the total storage capacity to be 109.4 MG.

Alternative T-4A(2) already requires impounded wastewater to be pumped from the denitrification reactors to Lagoon #2. As such, the increased water surface elevation will not require additional piping or pumps. This alternative will also result in the maximum water surface elevations in Lagoon #2 and #3 to balance. This will allow for gravity flow between the two ponds at all times. The elevation of the existing berms is currently 4418.25. By allowing the maximum water surface elevation in both Lagoons #2 and #3 to be 4415.25, 3 feet of freeboard will be provided. As such, no modifications to the existing berms will be required. The liner within Lagoon #2 will have to be extended up the berm to prevent seepage. This alternative will increase the water surface area Lagoon #2 from 7.0 acres to 7.19 acres. Seasonal storage volume calculations are provided in Appendix 7.

7.2.5.2.4 Irrigation System Hydraulics

Design agronomic rates discussed in Chapter 5 were referenced in conjunction with the City's existing 117 acres of available irrigation land to determine monthly average allowable discharge rates during the irrigation season. These flow rates are presented in Table 7-22. In order to feed the irrigation system at these rates and maintain average pump run times around 18 hr/day throughout the summer, the existing irrigation pump must be upsized to provide 1,800 gpm. It is also proposed to include automatic controls to operate the irrigation pump. This will eliminate the need for treated wastewater to be manually directed to the irrigation system, ultimately decreasing required O&M procedures.

Table 7-22 Design Irrigation Flow Rates				
Month	**Agronomic Rate** (inches)	**Irrigation Volume** (gallons)	**Flow Rate** (gpd)	**Estimated Average Pump Run Times** (hr/day)
May	6.73	21,382,930	1,425,529	13.2
June	13.73	43,623,718	1,454,124	13.5
July	19.11	60,717,353	1,958,624	18.1
August	17.76	56,428,058	1,820,260	16.9
September	9.15	29,071,888	1,938,126	17.9

The existing irrigation system includes 52 sprinkler heads, each with a 200-foot radius. To maintain the current configuration, it is suggested to run 6 sprinkler heads simultaneously. This equates to 300 gpm at each sprinkler head. Product literature pertaining to Nelson Irrigation's Big Gun sprinklers suggests approximately 300 gpm can provide an application radius of roughly 200 feet at pressures around 90 psi at the nozzle. Product literature is provided in Appendix 7. Should this alternative be selected, detailed hydraulic analysis during final design will be required to accurately select pump and spray nozzle sizing.

7.2.5.3 Map

This alternative requires no additional land acquisition or modification to the existing irrigation systems layout or existing lagoon footprint. As previously discussed, this alternative is not recommended in conjunction with treatment Alternatives T-4A(1) and T-4B. Should treatment Alternative T-5 be selected, no modification to the existing lagoons will be necessary. Alternative T-4A(2) will require some modifications to the existing lagoons. Liner will be extended up the dike of Lagoon #2 to allow the maximum water surface elevation to be increase from 4410.9 ft to 4415.35 ft. Additionally, Lagoon #2's overflow pipe will be raised from an invert elevation of 4414.00 ft to 4415.40 ft. The new hydraulic profile are illustrated in Figure 7-14.

7.2.5.4 Treatment During Construction

It is recommended that construction of Alternative D-4 occurs concurrently with treatment system upgrades. Careful planning and scheduling will be required to allow for at least one treatment lagoon to remain online at all times. Existing interpond piping will allow for each lagoon to be bypassed during construction. All construction activities within the lagoons should occur during the summer months when the ambient air temperature is elevated and biological treatment occurs most efficiently.

7.2.5.5 Operations and Maintenance

Few changes to the City's current O&M procedures are expected to result from Alternative D-4. The addition of an automatic controller on the irrigation pump will eliminate the need to manually direct effluent to the irrigation system. The additional pump capacity and elevated pump run times result in an increase in utilities cost for the irrigation system. **It estimated that from May to September, the energy cost for the irrigation pump will be approximately $6,000**. The electricity required for the

automatic controls is expected to be negligible. Utility cost calculations are provided in Appendix 7.

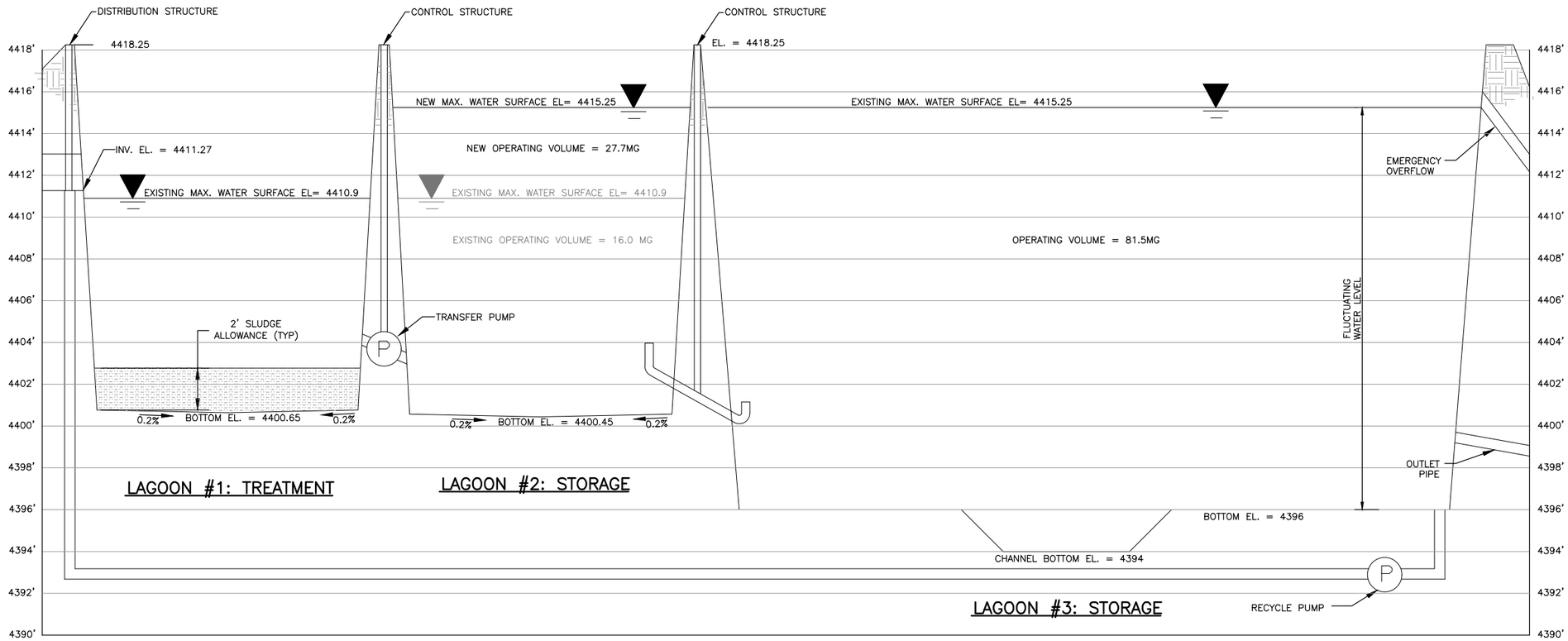
7.2.5.6 Cost Estimate

As previously discussed, improvements associated with this alternative are dependent on the selected treatment system upgrades. This disposal alternative is not considered compatible with Alternatives T-4A(1) and T-4B due to the significant costs required to expand the storage volume in Lagoon #3 by 27.4 MG.

If combined with Alternative T-4A(2), the estimated capital cost for Alternative D-4 is $123,000. With Alternative T-5, the estimated capital cost is $108,000. The primary cost difference is a result of the additional liner required with Alternative T-4A(2). Both estimates include budget to upsize the irrigation pump and install new nozzles on the existing sprinkler heads. The construction cost estimates to Alternative D-4 with Alternative T-4A(2) and T-5 are provided in Tables 7-23 and 1-24.

Table 7-23
Alternative D-4 With Treatment Alternative T-4A(2)
Construction Cost Estimate

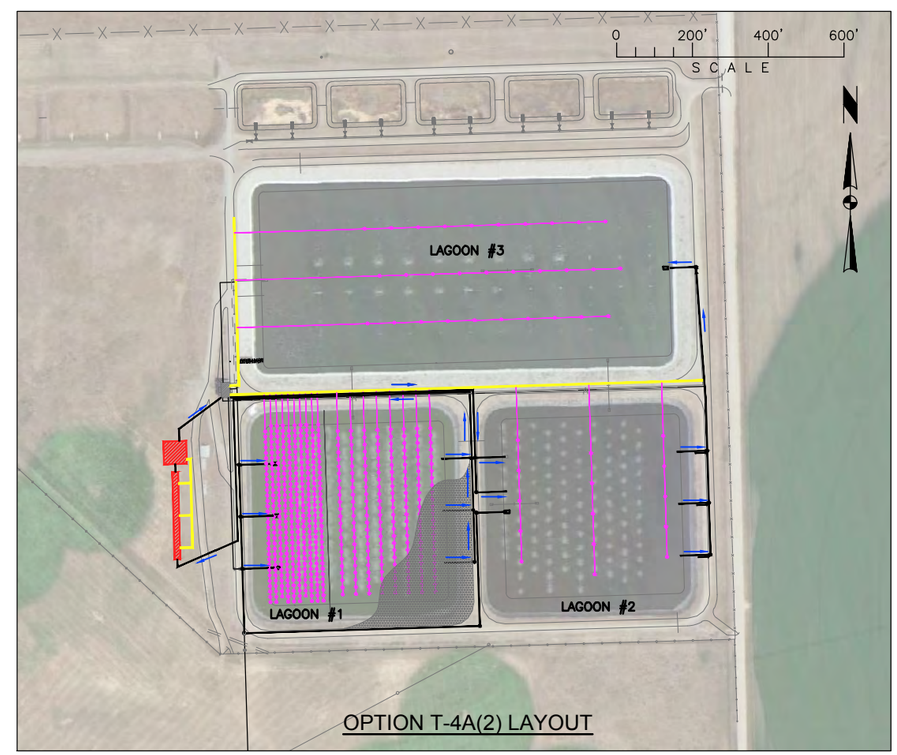
Description	Quantity	Unit	Unit Cost	Total Cost
Mobilization	5	%		$4,075
Liner Extension	9,000	SF	$1.10	$9,900
New Irrigation Pump	1	LS	$30,000	$30,000
New Sprinkler Head Orifices	1	LS	$10,000	$10,000
Layout and Construction Staking	1	LS	$20,000	$20,000
Miscellaneous Fieldwork or Materials	10,000	Units	$1	$10,000
Construction Materials Testing	2	%		$1,598
			Subtotal	**$85,573**
			Contingency	15%	$12,836
			Total Construction Estimate	**$98,409**
			Administrative, Engineering and Legal	25%	$24,602
			Estimated Total Cost (rounded to the nearest thousand)	**$123,000**



HYDRAULIC PROFILE

OPTION T-4A(2) LAYOUT LEGEND

- AERATION LATERALS
- AIR HEADERS
- INTERPOND PIPING
- NITRIFICATION/DENITRIFICTION REACTORS
- FLOW PATH



OPTION T-4A(2) LAYOUT

NOT FOR CONSTRUCTION

REV	DATE	REVISION

TD&H Engineering
tdhengineering.com

DRAWN BY: CJS
DESIGNED BY: CEVJ/DDN
QUALITY CHECK:
DATE: 2017-05-31
JOB NO. B16-048
FIELDBOOK

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

ALTERNATIVE D-4: SPRAY IRRIGATION UPGRADES WITH TREATMENT ALTERNATIVE T-4A(2)

FIG 7-11.DWG

FIGURE 7-14

J:\2016\B16-048 Belgrade Master Plan\CADD\CIVIL\FIG 7-11.dwg, 3/27/2018 4:25:01 PM, nmr

Table 7-24 Alternative D-4 With Treatment Alternative T-5 Construction Cost Estimate				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Mobilization	5	%		$3,570
New Irrigation Pump	1	LS	$30,000	$30,000
New Sprinkler Head Orifices	1	LS	$10,000	$10,000
Layout and Construction Staking	1	LS	$20,000	$20,000
Miscellaneous Fieldwork or Materials	10,000	Units	$1	$10,000
Construction Materials Testing	2	%		$1,400
			Subtotal	**$74,970**
			Contingency	15%	$11,246
			Total Construction Estimate	**$86,216**
			Administrative, Engineering and Legal	25%	$21,554
Estimated Total Cost (rounded to the nearest thousand)				**$108,000**

7.2.6 Alternative D-5: Additional Irrigation Area

7.2.6.1 Description

As discussed in Section 7.2.5, the existing 117 acres of irrigation area is adequate to serve the City of Belgrade beyond the design life proposed in this Master Plan with upgrades to the available storage and irrigation pump. However, conversations with the City personnel indicate additional irrigation land is desired to add flexibility to the system. This alternative entails constructing new irrigation laterals. This alternative may only be selected in conjunction with Alternative D-4 as additional storage and a larger capacity pump are required.

7.2.6.2 Design Criteria

7.2.6.2.1 State Regulations

The Circular DEQ-2 criteria identified in Alternative D-4 are applicable to Alternative D-5. Additionally, Chapter 120 of Circular DEQ-2 requires several criteria be addressed prior to approval of a new spray irrigation system and associated site. Essential documentation, reporting and analysis include the following:

- DNRC approved change to appropriation of water rights or written statement that no authorization is necessary
- Approved Nutrient Management Plan (NMP) to prevent over-application of nutrients at the approved irrigation sites
- Approved O&M procedures including startup and shutdown protocol
- Monitoring program during startup and periods of use included monthly wastewater effluent total nitrogen analysis, at a minimum
- Groundwater monitoring wells along with associated monitoring and testing for compliance, as required by DEQ

- Irrigation flow monitoring
- Final design report addressing serval site conditions including:
  - Wastewater effluent trace element and chemical loading testing, as required by DEQ
  - Groundwater, soil and agronomic data
  - Phosphorous breakthrough analysis (>50 years to nearest surface water)
- Record keeping data sheet

7.2.6.2.2 Required Storage

Although the total irrigation area will increase with this alternative, the irrigation flow rates will not increase. The purpose of the additional irrigation area is to provide disposal flexibility rather than additional disposal capacity. As such, the required storage discussed with Alternative D-4 is applicable to Alternative D-5.

7.2.6.2.3 System Hydraulics.

The additional irrigation area will not alter the system hydraulics from the requirements of Alternative D-4. As previously mentioned, the additional area will provide disposal flexibility. Under this scenario, the City can stagger the application area throughout the irrigation system in turn providing opportunities for equipment repair or drying periods.

7.2.6.3 Map

Two potential locations for additional irrigation land have been identified. Option 1 is located northwest of the existing treatment lagoons. A segment of this property is owned by the State of Montana; the remainder is owned by the Gallatin Airport Authority. Option 2 is located southeast of the existing lagoons, parallel to the current irrigation system. The land is currently owned by the Gallatin Airport Authority. Both locations include an additional 46 acres of irrigation land with 16 sprinkler heads, each with a 200 foot application radius.

A map of the two irrigation sites is provided in Figure 7-15.

7.2.6.4 Treatment During Construction

Construction of Alternative D-5 is not expected to impact the City's treatment system. Construction may occur at any time.

7.2.6.5 Operations and Maintenance

A minimal increase to O&M procedures is expected to maintain the addition irrigation area. Utility cost discussed in Alternative D-4 would be required for Alternative D-5.

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA

ALTERNATIVE D-5: ADDITIONAL IRRIGATION AREA

FIGURE 7-15
FIG 7-12.DWG

DRAWN BY: CJS
DESIGNED BY: CEV/JRDN
QUALITY CHECK:
DATE: 2017-05-31
JOB NO. B16-048
FIELDBOOK

TD&H Engineering
tdhengineering.com

REV	DATE	REVISION

NOT FOR CONSTRUCTION

7.2.6.6 Cost Estimate

Capital cost estimates for Alternative D-5 are provided in Table 7-25. With this alternative, the City may choose Option No. 1, Option No. 2 or both. The required transmission main length is slightly higher for Option 2, resulting in a slightly higher estimated capital cost. **Total construction cost estimates for Options 1 and 2 are $585,000 and $684,000, respectively. Should the City choose to construct additional irrigation in both locations, the total cost is estimated at $1,269,000.**

Table 7-25 Alternative D-5 – Construction Cost Estimate				
Option No. 1 (Northwest of Lagoons)				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Mobilization	5	%		$19,380
New Irrigation Laterals	8	EA	$12,000	$96,000
Sprinkler Heads	16	EA	$1,250	$20,000
Transmission Main	2,900	LF	$60	$174,000
New Valvess and System Controls	1	LS	$75,000	$75,000
Layout and Construction Staking	1	LS	$5,000	$5,000
Miscellaneous Fieldwork or Materials	10,000	Units	$1	$10,000
Construction Materials Testing	2	%		$7,600
			Subtotal	**$406,980**
		Contingency	15%	$61,047
			Total Construction Estimate	**$468,027**
		Administrative, Engineering and Legal	25%	$117,007
			Estimated Total Cost (rounded to the nearest thousand)	**$585,00**
Option No. 2 (South East of Lagoons)				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Mobilization	5	%		$22,644
New Irrigation Laterals	8	EA	$12,000	$96,000
Sprinkler Heads	16	EA	$1,250	$20,000
Transmission Main	3,800	LF	$60	$228,000
New Valves and System Controls	1	LS	$75,000	$75,000
Layout and Construction Staking	1	LS	$5,000	$5,000
Miscellaneous Fieldwork or Materials	20,000	Units	$1	$20,000
Construction Materials Testing	2	%		$8,880
			Subtotal	**$475,524**
		Contingency	15%	$71,329
			Total Construction Estimate	**$546,853**
		Administrative, Engineering and Legal	25%	$136,713
			Estimated Total Cost (round to the nearest thousand)	**$684,000**
			Combined Estimated Costs for Options No. 1 and No. 2	**$1,269,000**

8.0 FINAL PROJECT SELECTION

The following Chapter provides detailed comparisons of the collection, treatment and disposal alternative discussed in Chapters 6 and 7.

8.1 Recommended Collection System Improvements

The collection system improvements presented in Chapter 6 include solutions to accommodate future development in the City's planning boundary and improvements to existing infrastructure. The recommendations were prepared in June 2017 and may not reflect recent construction or development in the planning regions.

8.1.1 Future Development

The proposed improvements are based on conservative estimates of the peak hour flow and the anticipated impacts to existing infrastructure. It is recommended that the regional improvements be considered as new subdivisions, annexations, or other development are proposed outside City limits. It is not recommended to include the recommendations in the City's capital improvements plan as the timing of future development cannot be predicted. It is expected the northwest planning region will develop soon based on preliminary discussions between the City and several developers. Table 8-1 presents a summary of the proposed improvements in each planning region and the impacts to existing infrastructure. The extents of each planning region and the proposed improvements are provided in Figures 6-1 through 6-6 in Chapter 6.

Table 8-1 Capital Improvements to Accommodate Future Growth			
Planning Region	**Proposed Facilities**	**Connection Point**	**Downstream Infrastructure Affected by Development[(1)]**
Northwest	Gravity mains, Northwest Regional Lift Station, modifications to Cruiser Lift Station	Force Main in Cruiser Lane/Dry Creek Road	Force main in Cruiser Lane/Dry Creek Road and outfall sewer
Northeast	Gravity mains	Ryen Glenn Lift Station	Ryen Glenn Lift Station and force main
East	Gravity mains	Meadowlark Ranch subdivision	Meadowlark Ranch gravity mains, Meadowlark Lift Station and force main, and Ryen Glenn Lift Station and force main
Southeast	Gravity mains and new Interstate 90 crossing	Gravity main in Idaho Street	Idaho Street gravity main, Yellowstone Avenue gravity main, east sewer interceptor, and outfall sewer
South	Gravity mains	SID #78 east of Jackrabbit Lane	Existing Interstate 90 crossing, east sewer interceptor, and outfall sewer
Southwest	Gravity mains, Southwest Regional Lift Station	SID #78 Lift Station	SID #78 Lift Station, existing Interstate 90 crossing, east sewer interceptor, and outfall sewer
West	Gravity mains	Gravity main north OR south of West Madison Avenue	Existing Frontage Road crossing and Jackrabbit Lift Station
[(1)]Not including the wastewater treatment plant.			

8.1.2 Existing Infrastructure

Several improvements are recommended within the existing collection system; the majority are located at lift stations. As indicated in Chapter 6, most of the proposed projects consist of repairs or maintenance. The largest efforts include significant repairs to Cruiser and Farmers Lift Stations and replacing clay tile pipe gravity mains. Table 8-2 identifies the recommended improvements.

Several alternatives for the Cruiser Lift Station were presented in Chapter 6. The cost provided in Table 8-2 is for Alternative LS2-1 which would repair the lift station deficiencies independent of any development in the Northwest Regional Lift Station. It is recommended that any work at the Cruiser Lift Station be coordinated with development in the northwest planning region to minimize costs and to avoid redundant technical efforts.

Table 8-2 Existing Collection System Capital Improvements		
Project	**2018 Budgetary Cost**	**Comments**
Rehabilitate RV Dump Stations	N/A	City to consider options presented in Chapter 3.
Replace Clay Tile Pipe	N/A	Identify locations where clay tile is still in place.
Disconnect Storm Drain Inlet	N/A	Identify storm drain inlet location.
Jackrabbit Lift Station Improvements	$65,000	N/A
Cruiser Lift Station Improvements, Alternative LS2-1	$640,000	Coordinate improvements with Northwest Regional Lift Station
Farmers Lift Station Improvements	$510,000	Investigate the dye which has been observed in the wet well and valve vault.
SID #78 Lift Station Improvements	$65,000	Clean existing depth probe and re-evaluate pumping capacity.
Meadowlark Lift Station Improvements	$50,000	N/A
Ryen Glenn Lift Station Improvements	$65,000	N/A

8.2 Recommended Treatment System Improvements

Two alternatives discussed in Section 7.1 remain under consideration for proposed upgrades to the BWTP; Alternative T-4: Existing Lagoon Upgrades and Alternative T-5: Greenfield Mechanical Treatment. The remaining alternatives are both considered technically and logistically feasible and will provide sufficient treatment to maintain the City's compliance with the current discharge permit limitations for the 20-year design life defined in this Master Plan.

The feasible treatment alternatives are evaluated below based on an organized and systematic approach. The methodology has been applied to ensure a consistent and unbiased means of selecting the most beneficial alternative for the City of Belgrade. Each alternative was evaluated applying consistent criteria. These criteria include treatment during construction, available storage, operations and maintenance, and estimated capital costs. Each option will be scored within each criterion; lower scores indicate more beneficial options. Scores and ranking are summarized within the decision matrix provided in Section 8.2.5.

Regardless of final treatment system upgrades, it is recommended that the City install a headworks facility at the treatment plan's influent. This will provide mechanical pretreatment for TSS removal prior to primary wastewater treatment.

8.2.1 Treatment During Construction

The two remaining treatment alternatives have significantly different anticipated obstacles during construction. Alternative T-4 involves upgrading the existing lagoons. As a result, careful planning and scheduling during construction will be required. Construction within the two existing treatment basins may not occur simultaneously as one basin must remain active at all times. Additionally, construction should occur during warmer months, as the biological treatment processes occurs more efficiently at elevated temperatures. Alternative T-5 involves constructing a mechanical treatment plant completely independent of the existing treatment system. As such, treatment could continue with no interruptions as the new plant is constructed. *For these reasons, Alternative T-5 receives a score of 1 and Alternative T-4 is scored as a 2 for the treatment during construction criteria*.

8.2.2 Available Storage

As discussed in Chapter 7, each proposed alternative offers varying available storage volume. The sub-alternatives included in Alternative T-4 include either Lagoon #3 or both Lagoons #2 and #3 as storage basins, depending on final design layout. This results in 81.5 to 97.5 MG of available storage. Alternative T-5 includes all three-existing lagoon, or 113.5 MG of treated water storage. Because of the seasonal irrigation, higher volumes of available storage are advantageous. *For this criterion, Alternative D-5 is scored as a 1; Alternative D-4 is scored as a 2*.

8.2.3 Operations and Maintenance

Operational complexity varies significantly between the two remaining treatment alternatives. Each includes sensors and automatic controls. However, Alternative T-5 incorporates several additional mechanical components, associated monitoring, and control devices when compared to Alternative T-4. This will inherently increase the complexity of the required operational tasks.

Staffing requirements also influence final recommendations. Alternative T-4 proposes 2 to 3 FTE's. Initial training will be required to familiarize the operators with the new systems. It is estimated that Alternative T-5 will require between 6 to 7 FTE's. The complexity of a new mechanical treatment system will also require significantly greater initial and continued training to ensure the system is operated as designed while optimizing power use and treatment efficiency. Operator process and equipment knowledge will be crucial to provide reliable wastewater treatment.

To provide a quantitative comparison of the required O&M for each alternative, the present worth values calculated in Chapter 7 have been compared in Table 8-3. Annual O&M cost estimates account for primary expenses inclusive of estimated utility charges, chemical additives, general repairs and maintenance and staffing requirements. A real interest rate of 0.20% was applied over the 20-year design to project a present worth value. The estimated present worth value for Alternative T-4 ranges from approximately $13.1 million to $14.7 million; present worth approximations for Alternative T-5 range from $20.8 million to $26.5 million.

Table 8-3 Treatment Alternatives Operations and Maintenance Present Worth Comparison	
Alternative	**Cost Estimate**
T-4: Advanced Aeration with Tertiary Nutrient Removal	$13,115,000 to $14,719,000
T-5: Mechanical Treatment Plant	$20,811,000 to $26,510,000

Due to the elevated operational complexity, staffing requirement and estimated O&M present worth values, Alternative T-5 has been scored a 2 for Operations and Maintenance; Alternative T-4 has been given a score of 1.

8.2.4 Estimated Capital Costs

Capital cost estimates were originally presented and detailed in Chapter 7. The estimated costs for Alternative T-5 ranged from approximately $41.8 million to $49.9 million. The estimated construction costs for Alternative T-4 are roughly $17 to $18 million. Project cost information is summarized in Table 8-4. All capital cost estimates include budgets for construction contingency, engineering fees and legal/administrative costs.

Table 8-4 Treatment Alternatives Capital Cost Estimate	
Alternative	**Cost Estimate**
T-4: Advanced Aeration with Tertiary Nutrient Removal	$17,000,000 to $18,000,000
T-5: Mechanical Treatment Plant	$41,800,000 to $49,900,000

The estimated capital costs result in Alternative T-4 and T-5 being scored as 1 and 2, respectively.

8.2.5 Alternative Ranking Matrix

The alternative comparisons discussed throughout this section are summarized in Table 8-5. The two remaining alternatives were scored as either 1 or 2 for each criterion, with 1 indicating the most beneficial option. Conversations with the City have indicated the most important factor in choosing system improvements is capital costs. As such, the capital cost scoring has been multiplied by a factor of 2. The individual scores were then summed for each alternative. The lowest overall score suggests the most desirable alternative.

Table 8-5 Treatment Alternatives Decision Matrix		
Criteria	**T-4: Existing Lagoon Upgrades**	**T-5: Mechanical Treatment Plant**
Treatment During Construction	2	1
Available Storage	2	1
Operations and Maintenance	1	2
Estimated Capital Costs (x2)	2	4
Overall Score	**7**	**8**

8.2.6 Recommended Treatment Alternative

Based on the above discussion, it is recommended for the City to continue with Alternative T-4: Existing Lagoon Upgrades for final design. As detailed in Chapter 7, two sub-alternatives were considered with Alternative T-4. A Preliminary Engineering Report (PER) is recommended to provide the City with a more comprehensive understanding of the available options. Additionally, the PER may be referenced to apply for grant and low-interest loans.

8.3 Recommended Disposal System Improvements

It was estimated in Section 7.2 that the existing disposal systems can serve the City of Belgrade until the year 2032. However, it is recommended the City initiate planning and design of additional storage by 2029. Three disposal alternatives were found to be feasible in Chapter 7: Alternative D-3: Additional IP Bed, Alternative D-4: Spray Irrigation System Upgrades, and Alternative D-5: Additional Irrigation Area. Alternative D-5 must be implemented in conjunction with Alternative D-4 as the upsized pump and storage requirements are necessary for both alternatives.

The sections to follow compare the three remaining disposal alternatives. Four factors have been selected as the basis for this evaluation. The categories include disposal flexibility, permitting requirements, operations and maintenance, and estimated capital costs. As with the treatment alternatives, each disposal alternative has received a value with the lowest score representing the most beneficial option. Scores are tallied in the alternative ranking matrix, presented in section 8.3.5.

8.3.1 Disposal Flexibility

Conversations with City personnel indicate flexibility within the available disposal system is desired. By constructing a fourth IP Bed, Alternative D-3 would result in the irrigation system becoming unnecessary. However, it is suggested that the City maintain the existing land application system to allow staggered irrigation, in turn providing opportunities for equipment repair and drying periods. Additionally, the spray irrigation system would allow the City to decrease the discharge volumes to the IP beds, decreasing the likelihood of future permit violations.

Alternative D-4 would upgrade the existing irrigation system with additional storage and new pumps. It is estimated that to dispose of the design average day flow rate, the irrigation system

must operate at 73% capacity. This is assuming the three existing IP beds are operating at 100% capacity. If operated in conjunction with Alternative D-5, the flexibility of the City's disposal systems would increase further. Two potential locations for added irrigation land were presented in Chapter 7, each providing 46 acres of additional irrigation area. The inclusion of one of the irrigation locations would allow the irrigation system to operate at approximately 52% capacity. If additional irrigation is constructed at both suggested locations, the available irrigation area would increase to 209 acres and allow the system to operate at 41% capacity.

Because Alternative D-3 will allow the irrigation system to become unnecessary and strictly provide disposal flexibility, it has been given a score of 1. Alternative D-5 will require the irrigation system to operate between 41% and 53% capacity and Alternative D-4 requires the land application system to operate at 73% capacity. As such, Alterative D-5 and D-4 have received scores of 2 and 3 respectively for disposal flexibility.

8.3.2 Permitting Requirements

The three disposal options result in varying permitting requirements. Alternatives D-4 and D-5 include upgrades to the City's irrigation system. The irrigation systems are considered non-discharging systems by the Montana Department of Environmental Quality. Provided the City's application rates do not exceed approved agronomic rates, a discharge permit would not be required for Alternatives D-4 and D-5. The fourth IP bed suggested in Alternative D-3 would be considered a new or increased source of groundwater contamination by the DEQ. Modifications to the City's current permit would have to be renegotiated inclusive of a comprehensive non-degradation analysis. Although this process would not be extremely complicated, it is more complex than the permitting requirements for Alternatives D-4 and D-5. *For this reason, Alternatives D-4 and D-5 receive equal scores of 1 and Alternative D-3 receives a score of 2 for permitting requirements.*

8.3.3 Operations and Maintenance

The three remaining disposal alternatives are not expected to significantly increase overall O&M procedures for the City of Belgrade. Automatic controls are included in each to lessen labor requirements. Utility cost are expected to increase with each disposal alternative as higher volumes of wastewater will be pumped to the disposal sites.

For Alternative D-3, the fourth IP bed will eliminate the need for an irrigation system. A minor increases in the City's annual O&M budget is expected as a result of the additional pumping. As discussed in Chapter 7, the estimated annual utilities cost for Alternative D-3 is $21,400.

Alternative D-4 will require final disposal through the three existing IP beds as well as the upgraded irrigation system. The estimated energy cost of the irrigation system from May to September at design conditions is approximately $6,000; the estimated IP pumps' energy requirements result in an annual energy cost of approximately $15,000. This equates to a total annual energy cost of approximately $21,000.

As previously discussed, disposal Alternative D-5 requires improvements associated with Alternative D-4 as well. Alternative D-5 includes additional irrigation land to provide the City increased disposal flexibility. Required pump run times and anticipated energy requirements are equivalent to Alternative D-4.

There is not a significant difference in anticipated annual utility costs or O&M procedures between the three disposal alternatives. *As such, each alternative has been given an equal score of 2 for Operations and Maintenance*.

8.3.4 Estimated Capital Costs

Estimated capital cost for the three feasible disposal options are summarized in Table 8-6. Each estimate includes all items anticipated for the successful completion of required work as well as a 15% construction contingency, 25% for administrative, and legal and engineering fees. The estimated costs for an additional IP bed is $620,000. Upgrades to the existing irrigation system are estimated to cost between $108,000 and $123,000, depending on selected treatment system improvements, and the estimated capital cost for additional irrigation area is between $585,000 and $684,000, depending on irrigation system location (or $1,269,000 should the City elect to construct additional irrigation on both sites).

Table 8-6
Disposal Alternatives
Capital Cost Estimate

Alternative	Cost Estimate
D-3: Additional IP Bed	$620,000
D-4: Spray Irrigation System Upgrades	$108,000 to $123,000
D-5: Additional Irrigation Area	$585,000 to $684,000

Based on these capital cost estimates, Alternative D-4 is assigned a score of 1. Alternative D-3 and D-5 are approximately equivalent in estimated capital costs and therefore have been given a score of 2.

8.3.5 Alternative Ranking Matrix

Individual scoring of the three remaining disposal alternatives is summarized below in Table 8-7. As with the treatment alternatives, the individual scores were combined into an overall score. The lowest overall score indicates the most beneficial alternative.

Table 8-7
Disposal Alternative
Decision Matrix

Criteria	D-3: Additional IP Bed	D-4: Spray Irrigation System Upgrades	D-5: Additional Irrigation Area
Disposal Flexibility	1	3	2
Permitting Requirements	2	1	1
Operations and Maintenance	2	2	2
Estimated Capital Costs	2	1	2
Overall Score	**7**	**7**	**7**

8.3.6 Recommended Disposal Alternative

Based on population projections, the City will not be required to update the existing disposal system until the year 2032. As such, it is recommended the City prioritize other system improvements. Currently, all feasible disposal alternatives are considered equally beneficial. However, it is difficult to accurately predict capital costs and the City's needs a decade in advance. Therefore, disposal alternatives should be re-evaluated at the beginning of the design process.

9.0 SUMMARY AND CONCLUSIONS

9.1 SUMMARY

The following sections summarize the recommended improvements to the City of Belgrade's wastewater collection, treatment, and disposal systems.

9.1.1 Collection System

In general, the collection system is in good condition with isolated issues including older, clay tile sewer mains around West Main Street and issues at the Cruiser and Gallatin Farmers Lift Stations. Engineer's estimates of probable cost were prepared for improvements at each lift station: $640,000 for the Cruiser Lift Station and $510,000 at the Gallatin Farmers Lift Station. Smaller repairs are recommended at other lift stations to address sensor and SCADA issues and provide bypass pumping connections recommended by DEQ.

Seven future planning regions were delineated and referenced to develop collection system improvements including design flow rates, gravity trunk main sizing, lift station location, and force main diameter. The areas of future growth between the City limits and planning boundary were identified and delineated through discussions with City personnel and by reviewing property ownership and aerial imagery. The design peak hour flow for each future development region was estimated by applying the City's design standards and the mapped zoning. Future gravity mains, lift stations, and force mains were sized to accommodate planning region peak hour flows. Improvements include a Northwest Regional Lift Station to serve areas north of Cruiser Lane, a Southwest Regional Lift Station to serve future development west of Special Improvement District #78, upsizing critical sewer crossings and interceptors, and upsizing existing lift stations. Cost estimates were not prepared for planning region improvements since, in most cases, it is difficult to predict when the development will occur and how costs may be distributed between the City and the developer.

9.1.2 Treatment System

As a whole, the City of Belgrade has a well maintained, properly functioning wastewater treatment system. However, the Belgrade area is expected to maintain its elevated population growth rate. As such, upgrades to the BWTP are necessary to provide reliable wastewater treatment as the City's raw wastewater flows increase. A number of potential solutions were preliminarily considered; two were believed to be technically and logistically feasible. These alternatives include upgrades to the existing system and a new greenfield mechanical system. Upgrades to the existing system may include a new advanced aeration system with tertiary nutrient removal or a new SBR with biosolids storage within the existing lagoons. Possible greenfield mechanical systems include a fully mechanical SBR with solids digestion, 5-Stage Bardenpho, or MBR. Conversations with City personnel have indicated the most desirable option will result in a reliable, easily maintained system at a low capital cost. Due to the high construction cost and O&M complexity of the greenfield mechanical systems, it is recommended that City proceed with upgrades to the existing system.

Preliminary capital cost estimates suggest upgrades to the system will range from $17 million to $18 million. As previously stated, upgrades to the system may include a new SBR with solids handling in the existing lagoons or advanced aeration in the existing lagoons with additional treatment for TN removal. It is suggested the City complete a PER in the year 2020 to apply for financial assistance for the proposed upgrades. During preparation of the PER, a more detailed

analysis of optional upgrades and conversations with City staff regarding specific needs and desires can be completed; at which time treatment system recommendations will be finalized. Due to inflation and the preliminary nature of the current cost estimate, the City of Belgrade should budget for $20 million in capital costs for the upgrades. This value will provide a sufficiently conservative financial plan.

9.1.3 Disposal System

Three feasible disposal alternatives were detailed within the Master Plan: installation of a fourth IP bed, upgrades to the existing irrigation system and construction of additional irrigation area. However, based on previously discussed population projections and assuming upgrades to the treatment system for increased TN removal, the City is not expected to need additional disposal infrastructure until the year 2032. Evaluation of each alternative all three are considered equally beneficial. Estimated capital costs ranged from approximately $100,000 for upgrades to the existing irrigation system to $650,000 for a fourth IP bed.

It is recommended that the City prioritize more pressing system upgrades at this time. Improvements to the disposal system should be considered by 2029, to ensure a completed system by 2032. Capital cost and needs of the City should be re-evaluated at that time.

9.2 CONCLUSIONS

This Master Plan provides the City with recommended improvements to its wastewater system and a general timeline for implementing the treatment and disposal system improvements. As documented elsewhere in this report, the City's wastewater treatment system will reach capacity around the year 2022. It is recommended that the City's primary wastewater system planning prioritize recommended treatment alternatives necessary to ensure operations in 2023.

An independent Rate Study is currently considering infrastructure improvements in order to budget for projects recommended in the Master Plan. It is expected that conventional grant and loan funding options will be considered in the Rate Study and pursued in the next funding cycle. A Preliminary Engineering Report (PER) is required to submit for construction funding from the following programs: Montana Department of Commerce's Community Development Block Grant (CDBG) and Treasure State Endowment Program (TSEP), the Montana DEQ's Water Pollution Control State Revolving Fund (WPC SRF) Loan Program, the USDA's Rural Development (RD) program, or the Montana Department of Natural Resource and Conservation's (DNRC) Renewable Resource Grant and Loan (RRGL) Program. Planning grants, to defray the costs of a PER, are also available from many of the agencies.

The following sections provide a general discussion of the grant and loan funds available as well as a proposed funding strategy.

1. Montana Renewable Resource Grant and Loan Program (RRGL)-Department of Natural Resources and Conservation (DNRC)

   The Montana legislature established the RRGL Program to conserve, develop, manage and protect Montana's renewable resources. The program is administered by the Resource Development Bureau of the Department of Natural Resource and Conservation (DNRC). Funds are appropriated directly through the legislature the following year based on recommendations from DNRC. The legislature must approve the funding for the grant prior to start of the project. The

grant funding limits are $125,000. The loan amount limit is the maximum amount that can be borrowed by the local government and repaid by issuing bonds. Applicants are notified of their ranking by the fall of the year the application was submitted.

2. Treasure State Endowment Program (TSEP)

This State-funded program is administered by the Montana Department of Commerce (MDOC). The funding is derived from a portion of the Coal Tax Trust Fund interest. The TSEP program provides matching grants for qualifying projects up to $750,000. In order to qualify for the maximum grant of $750,000, the applicant's user rates must be 150% of the communities target rate upon completion of proposed project. If user rates are projected to be between 125% and 150% of the target rate the applicant may apply for a maximum grant of $625,000. Applicants with user rates under 125% of the target rate can apply for a maximum of $500,000. In addition, the grant must not exceed $20,000 per benefited household and be no greater than 50% of the eligible project expenses. A local match of 50% is required by TSEP and can consist of cash, other grants, or loans.

Applicants for the TSEP program are accepted every other year by the Montana Department of Commerce (MDOC) and submitted to the legislature for review and approval for funding. The applications are accepted in May of the year prior to the next legislative session (even numbered years) and approved the following year. The applications are generally notified of rank in fall of the year the application was submitted.

3. Community Development Block Grant (CDBG) Program

Montana's CDBG program is a federally funded competitive grant program intended to assist communities of less than 50,000 people with primary benefits to low and moderate income (LMI) persons. In order to be eligible, a community must have at least 51% of the population considered LMI. The funds are frequently pooled with other federal, state or local resources to improve infrastructure including water and wastewater facilities. The maximum grant awarded for a public facility project is $450,000 or $20,000 per LMI household to be benefitted by the project, whichever is lower. It is required that 25% of the grant funds are matched. Applications must be submitted along with the Uniform Application by early April each year. The chosen applicants receive award letters by early fall of the year of application.

4. State Revolving Fund Loan (SRF)

The SRF program was initiated by the Montana legislature for water and wastewater projects using federal seed money. This program provides at or below market interest rates to qualifying entities. The loans are funded using capitalization grants from EPA and are matched with state issued general obligation bonds. Water Pollution Control (WPC) SRF loans are specifically intended for water pollution control projects related to wastewater treatment systems.

In order to be eligible for this type of funding, the project must be added to the SRF Project Priority List and Intended Use Plan. The annual process to identify projects eligible for SRF funds begins in July and applications must be submitted with the Uniform Application. Early notification by the applicant is important to be included on the priority list. A project remains on the list until it has been completed, regardless of funding sources used to finance the project.

SRF loan terms are currently 2.5% for up to twenty years. A revenue bond requires debt service and coverage of 110% for existing districts or towns. Loan amounts are limited to the borrower's ability to pay and the amount of SRF funds available. Loans must be secured by a bond or note. If the sewer rate is higher than the TSEP target rates, the community is eligible for loan forgiveness. Loan forgiveness is only available for up to 50% the loan.

5. U.S. Department of Agriculture Rural Development (RD)

The U.S. Department of Agriculture Rural Development (RD) program provides grants and loans to rural communities of less than 10,000 people; therefore, Belgrade is not eligible for RD funding.

While programs such as SRF and CDBG have open or annual application cycles, the remaining grant programs are awarded biannually. Applications are accepted during even years in the spring. Completing a PER and grant applications for the 2018 application deadlines is not feasible considering the limited time available, however it is recommended that the City submit in 2020. If the City is also considering grant funding for a water improvements project, it is recommended that only one project be submitted during a given grant cycle. Grant funding is extremely competitive and subject to legislative approval and federal funding allocations. Grant applications submitted in 2020 would be subject to approval during the 2021 Legislative session (2023 Biennium). If the project ranks well and funding is approved, design could begin in the summer of 2021 to and bid documents ready in early 2022. Bidding should occur soon after to allow for delivery of long-lead equipment ahead of the 2022 construction season.

Recent discussions with the DNRC indicates planning grants will be available in the Fall of 2018. It is recommended the City contact DNRC and other perspective planning grant programs early to confirm funding availability and anticipated grant allowances.

10.0 ABBREVIATIONS

The following abbreviations are referenced throughout the Master Plan:

ADF	Average day flow
AE2S	Advanced Engineering and Environmental Solution, Inc
AGS	Aerobic Granular Sludge
ARM	Administrative Rules of Montana
BNR	Biological Nutrient Removal
BOD	Biological Oxygen Demand
BWTP	Belgrade Wastewater Treatment Plant
BZN	Bozeman-Yellowstone International Airport
CDBG	Community Development Block Grant
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CFU	Colony Forming Unit
CS1	Control Structure 1
CS2	Control Structure 2
CS3	Control Structure 3
CS4	Control Structure 4
CS5	Control Structure 5
CS6	Control Structure 6
CS7	Control Structure 7
DEQ	Department of Environmental Quality
DI	Ductile Iron
DMR	Discharge Monitoring Reports
DNRC	Department of Natural Resource and Conservation
DO	Dissolved Oxygen
EPA	U.S Environmental Protection Agency
EPOCC	Engineer's Opinion of Probable Construction Cost
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FTE	Full Time Employee
GAA	Gallatin Airport Authority
GIS	Geographic information system
gpcd	Gallons per capita day
gpd	Gallons per day
gpm	Gallons per minute
GWIC	Ground Water Information Center
HDPE	High Density Polyethylene
HMI	Human Machine Interface
HP	Horsepower
ICEAS	Intermittent Cycle Extended Aeration System
I/I	Inflow and infiltration
IP	Infiltration/Percolation
kW	Kilowatts
kWh	Kilowatt-hours
LF	Linear feet
MBMG	Montana Bureau of Mines and Geology
MBR	Membrane Bioreactor

MCA	Montana Code Annotated
MDEQ	Montana Department of Environmental Quality
MG	Million gallons
MGD	Million gallons per day
MGWPCS	Montana Groundwater Pollution Control System
MLSS	Mixed Liquor Suspended Solids
MPWSS	Montana Public Works Standard Specifications
MWQA	Montana Water Quality Act
N_2	Diatomic Nitrogen
NFIP	National Flood Insurance Program
NMP	Nutrient Management Plan
NRCS	Natural Resources and Conservation Service
NED	National Elevation Dataset
O&M	Operation and maintenance
PAO	Phosphorous Accumulation Organism
PER	Preliminary Engineering Report
PFD	Process Flow Diagram
psi	Pounds per square inch
PLC	programmable Logic Controller
ppd	pounds per day
PVC	Polyvinyl chloride
RAS	Return Activated Sludge
RPM	Revolutions per minute
RRGL	Renewable Resource Grant and Loan
RTU	Remote telemetry unit
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control and Data Acquisition
scfm	Standard cubic feet per minute
SF	Square feet
SID	Special Improvement District
SRF	State Revolving Fund
SRT	Solids Retention Time
TDH	Total dynamic head
TD&H	Thomas, Dean and Hoskins
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TOC	Top of Casing
TP	Total Phosphorous
TSS	Total Suspended Solids
TSEP	Treasure State Endowment Program
VFD	Variable Frequency Drive
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WPCSRF	Water Pollution Control State Revolving Fund
WRCC	Western Regional Climate Center
WRF	Water Reclamation Facility
USDA	United States Department of Agriculture

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APPENDIX 2

WEB SOIL SURVEY

United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Gallatin County Area, Montana

April 18, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

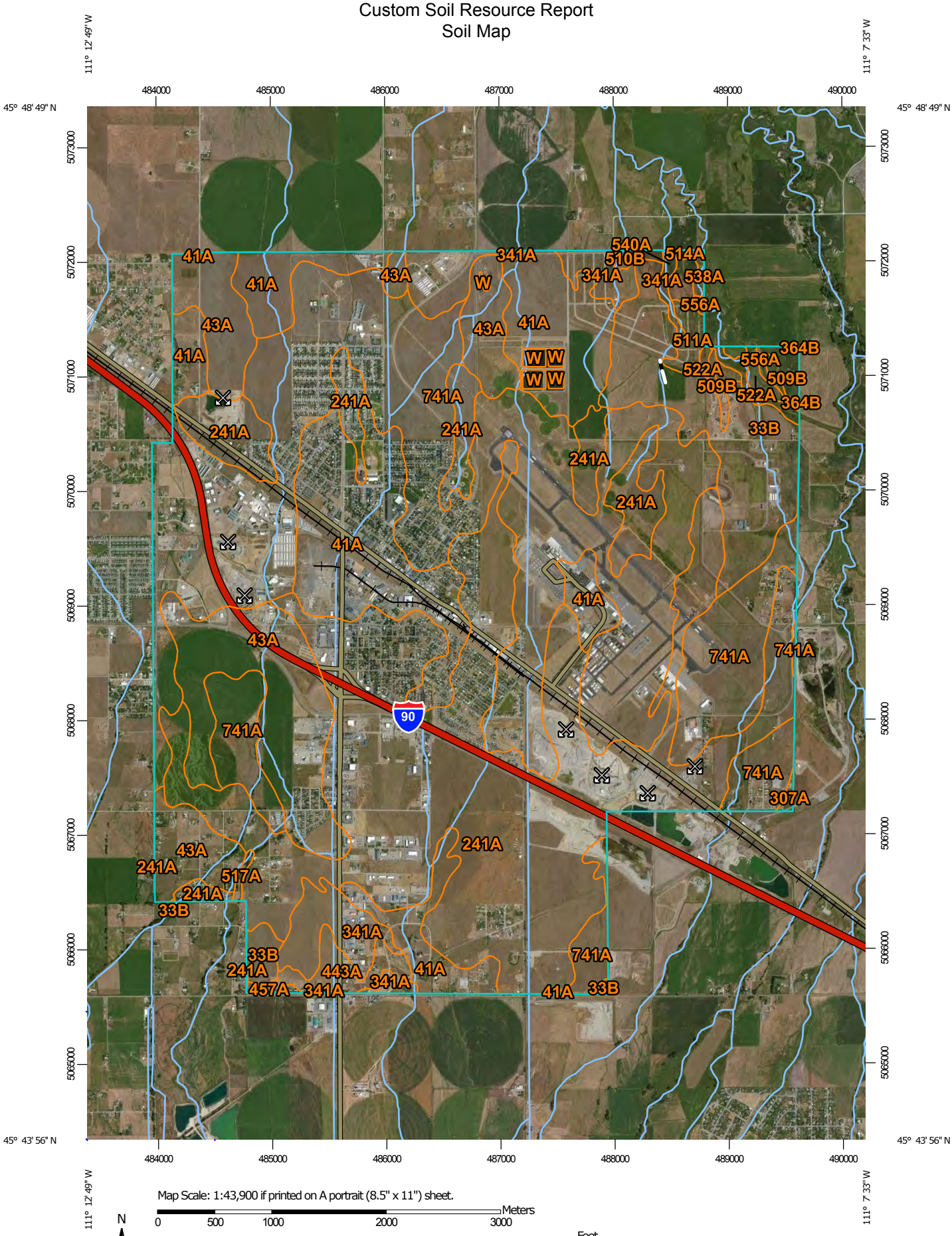
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:43,900 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 500 1000 2000 3000

Feet: 0 2000 4000 8000 12000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Gallatin County Area, Montana
Survey Area Data: Version 20, Sep 19, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 28, 2011—Aug 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Gallatin County Area, Montana (MT622)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
33B	Attewan clay loam, 0 to 4 percent slopes	462.6	5.8%
41A	Beaverell loam, 0 to 2 percent slopes	1,154.8	14.4%
43A	Beavwan loam, 0 to 2 percent slopes	815.1	10.2%
241A	Beaverell cobbly loam, 0 to 2 percent slopes	2,490.5	31.1%
307A	Sudworth silty clay loam, 0 to 2 percent slopes	6.1	0.1%
341A	Beaverell-Beavwan loams, moderately wet, 0 to 2 percent slopes	200.9	2.5%
364B	Straw silty clay loam, 0 to 4 percent slopes	0.1	0.0%
443A	Beavwan loam, moderately wet, 0 to 2 percent slopes	78.4	1.0%
457A	Turner loam, moderately wet, 0 to 2 percent slopes	2.4	0.0%
509B	Enbar loam, 0 to 4 percent slopes	40.6	0.5%
510B	Meadowcreek loam, 0 to 4 percent slopes	6.2	0.1%
511A	Fairway silt loam, 0 to 2 percent slopes	35.7	0.4%
514A	Soapcreek silty clay loam, 0 to 2 percent slopes	7.8	0.1%
517A	Saypo silt loam, 0 to 2 percent slopes, drained	6.8	0.1%
522A	Enbar clay loam, 0 to 2 percent slopes	28.0	0.4%
538A	Tetonview silt loam, 0 to 2 percent slopes	0.3	0.0%
540A	Tetonview-Newtman complex, 0 to 2 percent slopes	23.9	0.3%
556A	Threeriv-Bonebasin loams, 0 to 2 percent slopes	35.0	0.4%
741A	Beaverell-Beavwan complex, 0 to 2 percent slopes	2,576.8	32.2%
W	Water	29.3	0.4%
Totals for Area of Interest		**8,001.3**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas

shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Gallatin County Area, Montana

33B—Attewan clay loam, 0 to 4 percent slopes

Map Unit Setting

National map unit symbol: 56q2
Elevation: 4,150 to 4,650 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 95 to 115 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Attewan and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Attewan

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 6 inches: clay loam
Bt - 6 to 12 inches: clay loam
Bk - 12 to 26 inches: gravelly loam
2C - 26 to 60 inches: very gravelly loamy sand

Properties and qualities

Slope: 0 to 4 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Clayey (Cy) 9-14" p.z. (R044XS330MT)
Hydric soil rating: No

Minor Components

Beaverell

Percent of map unit: 5 percent

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Beavwan

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

41A—Beaverell loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56s2
Elevation: 4,200 to 4,650 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 95 to 115 days
Farmland classification: Farmland of local importance

Map Unit Composition

Beaverell and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Beaverell

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 7 inches: loam
B - 7 to 20 inches: very cobbly clay loam
2Bk1 - 20 to 24 inches: extremely cobbly coarse sandy loam
2Bk2 - 24 to 60 inches: extremely cobbly loamy coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.4 inches)

Interpretive groups
Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Minor Components

Beaverell
Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Attewan
Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

43A—Beavwan loam, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 56sh
Elevation: 4,350 to 4,650 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 95 to 115 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Beavwan and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Beavwan

Setting
Landform: Stream terraces
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 5 inches: loam
Bt1 - 5 to 15 inches: clay loam
2Bt2 - 15 to 22 inches: extremely cobbly sandy clay loam
2Bk1 - 22 to 28 inches: extremely cobbly sandy loam
2Bk2 - 28 to 60 inches: very gravelly coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Available water storage in profile: Low (about 4.4 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Minor Components

Beaverell

Percent of map unit: 10 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Attewan

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

241A—Beaverell cobbly loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56mx

Elevation: 4,250 to 4,650 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 95 to 115 days
Farmland classification: Farmland of local importance

Map Unit Composition

Beaverell and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Beaverell

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 7 inches: cobbly loam
B - 7 to 20 inches: very cobbly clay loam
2Bk1 - 20 to 24 inches: extremely cobbly coarse sandy loam
2Bk2 - 24 to 60 inches: extremely cobbly loamy coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: Unranked

Minor Components

Beaverell

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) RRU 46-C 10-14" p.z. (R046XC491MT)
Hydric soil rating: No

Attewan

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Scravo

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Droughty-Steep (SiDrStp) 9-14" p.z. (R044XS340MT)
Hydric soil rating: No

307A—Sudworth silty clay loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56pj
Elevation: 4,400 to 4,650 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Sudworth and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sudworth

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A1 - 0 to 7 inches: silty clay loam
A2 - 7 to 24 inches: loam
Bk - 24 to 29 inches: loam
2C - 29 to 60 inches: extremely gravelly sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 48 to 96 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups
Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Clayey (Cy) 15-19" p.z. (R044XS350MT)
Hydric soil rating: No

Minor Components

Enbar
Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Subirrigated (Sb) 15-19" p.z. (R044XS359MT)
Hydric soil rating: No

Nesda
Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 15-19" p.z. (R044XS354MT)
Hydric soil rating: No

Turner
Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) 15-19" p.z. (R044XS355MT)
Hydric soil rating: No

341A—Beaverell-Beavwan loams, moderately wet, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 56q3
Elevation: 4,100 to 4,750 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 95 to 115 days

Farmland classification: Farmland of local importance

Map Unit Composition

Beaverell and similar soils: 60 percent
Beavwan and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Beaverell

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 7 inches: loam
B - 7 to 20 inches: very cobbly clay loam
2Bk1 - 20 to 24 inches: extremely cobbly coarse sandy loam
2Bk2 - 24 to 60 inches: extremely cobbly loamy coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 48 to 96 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: Unranked

Description of Beavwan

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 5 inches: loam
Bt1 - 5 to 15 inches: clay loam
2Bt2 - 15 to 23 inches: extremely cobbly sandy clay loam
2Bk - 23 to 60 inches: extremely cobbly loamy sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 48 to 96 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Available water storage in profile: Low (about 4.1 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Minor Components

Beaverell

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Attewan

Percent of map unit: 3 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Beavwan, channeled

Percent of map unit: 2 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

364B—Straw silty clay loam, 0 to 4 percent slopes

Map Unit Setting

National map unit symbol: 56qv

Elevation: 4,400 to 5,100 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Straw and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Straw

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

A - 0 to 18 inches: silty clay loam
Bk - 18 to 60 inches: loam

Properties and qualities

Slope: 0 to 4 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 10.8 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Clayey (Cy) 15-19" p.z. (R044XS350MT)
Hydric soil rating: No

Minor Components

Enbar

Percent of map unit: 10 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Subirrigated (Sb) 15-19" p.z. (R044XS359MT)
Hydric soil rating: No

Sudworth

Percent of map unit: 5 percent
Landform: Stream terraces

Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) 15-19" p.z. (R044XS350MT)
Hydric soil rating: No

443A—Beavwan loam, moderately wet, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56sn
Elevation: 4,450 to 4,700 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 95 to 115 days
Farmland classification: Farmland of local importance

Map Unit Composition

Beavwan and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Beavwan

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 5 inches: loam
Bt1 - 5 to 15 inches: clay loam
2Bt2 - 15 to 23 inches: extremely cobbly sandy clay loam
2Bk - 23 to 60 inches: extremely cobbly loamy sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 48 to 96 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Available water storage in profile: Low (about 4.1 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)

Hydric soil rating: No

Minor Components

Beaverell

Percent of map unit: 10 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Attewan

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) 9-14" p.z. (R044XS330MT)
Hydric soil rating: No

457A—Turner loam, moderately wet, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56tb
Elevation: 4,300 to 5,200 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Turner and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Turner

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 6 inches: loam
Bt - 6 to 12 inches: clay loam
Bk - 12 to 26 inches: clay loam
2C - 26 to 60 inches: very gravelly loamy sand

Properties and qualities

Slope: 0 to 2 percent

Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 48 to 96 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 5.4 inches)

Interpretive groups
Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) 15-19" p.z. (R044XS355MT)
Hydric soil rating: No

Minor Components

Beaverton
Percent of map unit: 5 percent
Landform: Stream terraces, alluvial fans
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 15-19" p.z. (R044XS354MT)
Hydric soil rating: No

Meadowcreek
Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Subirrigated (Sb) 15-19" p.z. (R044XS359MT)
Hydric soil rating: No

Turner
Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) 15-19" p.z. (R044XS355MT)
Hydric soil rating: No

509B—Enbar loam, 0 to 4 percent slopes

Map Unit Setting
National map unit symbol: 56vp
Elevation: 4,400 to 6,000 feet
Mean annual precipitation: 15 to 19 inches

Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Enbar and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Enbar

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

A - 0 to 22 inches: loam
Cg - 22 to 49 inches: sandy loam
2C - 49 to 60 inches: very gravelly loamy sand

Properties and qualities

Slope: 0 to 4 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Ecological site: Subirrigated (Sb) 15-19" p.z. (R044XS359MT)
Hydric soil rating: No

Minor Components

Nythar

Percent of map unit: 10 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

Straw

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear

Across-slope shape: Linear
Ecological site: Silty (Si) 15-19" p.z. (R044XS355MT)
Hydric soil rating: No

510B—Meadowcreek loam, 0 to 4 percent slopes

Map Unit Setting

National map unit symbol: 56vt
Elevation: 4,200 to 5,950 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Meadowcreek and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Meadowcreek

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 11 inches: loam
Bg - 11 to 25 inches: silt loam
2C - 25 to 60 inches: very gravelly sand

Properties and qualities

Slope: 0 to 4 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water storage in profile: Low (about 5.1 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Subirrigated (Sb) 15-19" p.z. (R044XS359MT)
Hydric soil rating: No

Minor Components

Blossberg

Percent of map unit: 10 percent
Landform: Terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

Beaverton

Percent of map unit: 5 percent
Landform: Alluvial fans, stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 15-19" p.z. (R044XS354MT)
Hydric soil rating: No

511A—Fairway silt loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56vv
Elevation: 4,100 to 4,950 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Fairway and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fairway

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

A - 0 to 15 inches: silt loam
Cg - 15 to 46 inches: silt loam
2Cg - 46 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)
Available water storage in profile: High (about 9.1 inches)

Interpretive groups
Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: Subirrigated (Sb) 9-14" p.z. (R044XS343MT)
Hydric soil rating: No

Minor Components

Blossberg
Percent of map unit: 10 percent
Landform: Terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

Meadowcreek
Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Subirrigated (Sb) 15-19" p.z. (R044XS359MT)
Hydric soil rating: No

514A—Soapcreek silty clay loam, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 56vz
Elevation: 4,200 to 6,000 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Soapcreek and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Soapcreek

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium

Typical profile

A - 0 to 15 inches: silty clay loam
Bk - 15 to 46 inches: silty clay loam
Bg - 46 to 60 inches: stratified fine sandy loam to silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)
Available water storage in profile: High (about 9.9 inches)

Interpretive groups

Land capability classification (irrigated): 4w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Ecological site: Subirrigated (Sb) 9-14" p.z. (R044XS343MT)
Hydric soil rating: No

Minor Components

Meadowcreek

Percent of map unit: 10 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Saline Subirrigated (SSb) 9-14" p.z. (R044XS333MT)
Hydric soil rating: No

Blossberg

Percent of map unit: 5 percent
Landform: Terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

517A—Saypo silt loam, 0 to 2 percent slopes, drained

Map Unit Setting

National map unit symbol: 56w2
Elevation: 4,200 to 4,600 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 95 to 115 days
Farmland classification: Farmland of local importance

Map Unit Composition

Saypo and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Saypo

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

A - 0 to 10 inches: silt loam
Bk - 10 to 21 inches: silt loam
Bkg - 21 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 48 to 96 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 40 percent
Salinity, maximum in profile: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Moderate (about 7.7 inches)

Interpretive groups

Land capability classification (irrigated): 4w
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: C
Ecological site: Saline Subirrigated (SSb) 9-14" p.z. (R044XS333MT)
Hydric soil rating: No

Minor Components

Saypo

Percent of map unit: 10 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Saline Subirrigated (SSb) 9-14" p.z. (R044XS333MT)
Hydric soil rating: No

Binna

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Saline Subirrigated (SSb) 9-14" p.z. (R044XS333MT)
Hydric soil rating: No

522A—Enbar clay loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56w9
Elevation: 4,300 to 5,850 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Enbar and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Enbar

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

A - 0 to 16 inches: clay loam
Cg - 16 to 53 inches: clay loam
2C - 53 to 60 inches: very gravelly loamy sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.6 inches)

Interpretive groups
Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Ecological site: Subirrigated (Sb) 15-19" p.z. (R044XS359MT)
Hydric soil rating: No

Minor Components

Sudworth
Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) 15-19" p.z. (R044XS350MT)
Hydric soil rating: No

Straw
Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) 15-19" p.z. (R044XS355MT)
Hydric soil rating: No

Nythar
Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

538A—Tetonview silt loam, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 56wq
Elevation: 4,150 to 4,450 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 110 days

Farmland classification: Farmland of local importance

Map Unit Composition

Tetonview and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tetonview

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 10 inches: silt loam
Bkg - 10 to 36 inches: silt loam
Cg - 36 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 35 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water storage in profile: High (about 10.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: Wet Meadow (WM) 9-14" p.z. (R044XS349MT)
Hydric soil rating: Yes

Minor Components

Lamoose

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 9-14" p.z. (R044XS349MT)
Hydric soil rating: No

Newtman

Percent of map unit: 5 percent
Landform: Terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 9-14" p.z. (R044XS349MT)

Hydric soil rating: Yes

Saypo

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Saline Subirrigated (SSb) 9-14" p.z. (R044XS333MT)
Hydric soil rating: No

540A—Tetonview-Newtman complex, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56wv
Elevation: 4,100 to 5,150 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: Farmland of local importance

Map Unit Composition

Tetonview and similar soils: 50 percent
Newtman and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tetonview

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 10 inches: silt loam
Bkg - 10 to 36 inches: silt loam
Cg - 36 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 35 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)

Available water storage in profile: High (about 10.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: Wet Meadow (WM) 9-14" p.z. (R044XS349MT)
Hydric soil rating: No

Description of Newtman

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

Oe - 0 to 9 inches: mucky peat
A - 9 to 15 inches: silty clay loam
Cg - 15 to 24 inches: silty clay loam
2Cg - 24 to 60 inches: very gravelly sandy clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)
Available water storage in profile: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: Wet Meadow (WM) 9-14" p.z. (R044XS349MT)
Hydric soil rating: Yes

Minor Components

Water

Percent of map unit: 4 percent

Saypo

Percent of map unit: 3 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Saline Subirrigated (SSb) 9-14" p.z. (R044XS333MT)
Hydric soil rating: No

Threeriv

Percent of map unit: 3 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

556A—Threeriv-Bonebasin loams, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 56x4
Elevation: 4,000 to 6,100 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: Not prime farmland

Map Unit Composition

Threeriv and similar soils: 45 percent
Bonebasin and similar soils: 45 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Threeriv

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

Oe - 0 to 4 inches: moderately decomposed plant material
Ag - 4 to 9 inches: loam
Cg - 9 to 29 inches: stratified sandy loam to silty clay loam
2Cg - 29 to 60 inches: extremely gravelly loamy sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)

Available water storage in profile: Moderate (about 7.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

Description of Bonebasin

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

Oa - 0 to 4 inches: muck
A - 4 to 15 inches: loam
Cg - 15 to 25 inches: stratified sandy loam to silty clay loam
2C - 25 to 60 inches: very gravelly coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

Minor Components

Threeriv

Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: No

Blossberg

Percent of map unit: 5 percent
Landform: Marshes
Down-slope shape: Linear
Across-slope shape: Linear

Ecological site: Wet Meadow (WM) 15-19" p.z. (R044XS365MT)
Hydric soil rating: Yes

741A—Beaverell-Beavwan complex, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 570q
Elevation: 4,100 to 5,000 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 95 to 115 days
Farmland classification: Farmland of local importance

Map Unit Composition

Beaverell and similar soils: 55 percent
Beavwan and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Beaverell

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 7 inches: cobbly loam
B - 7 to 20 inches: very cobbly clay loam
2Bk1 - 20 to 24 inches: extremely cobbly coarse sandy loam
2Bk2 - 24 to 60 inches: extremely cobbly loamy coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6s

Hydrologic Soil Group: B
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Description of Beavwan

Setting

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 5 inches: loam
Bt1 - 5 to 15 inches: clay loam
2Bt2 - 15 to 22 inches: extremely cobbly sandy clay loam
2Bk1 - 22 to 28 inches: extremely cobbly sandy loam
2Bk2 - 28 to 60 inches: very gravelly coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Available water storage in profile: Low (about 4.4 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

Minor Components

Attewan

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) 9-14" p.z. (R044XS330MT)
Hydric soil rating: No

Beaverell

Percent of map unit: 5 percent
Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) RRU 46-C 10-14" p.z. (R046XC491MT)
Hydric soil rating: No

Beaverell, channeled

Percent of map unit: 5 percent

Landform: Stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)
Hydric soil rating: No

W—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Physical Properties

Soil Physical Properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

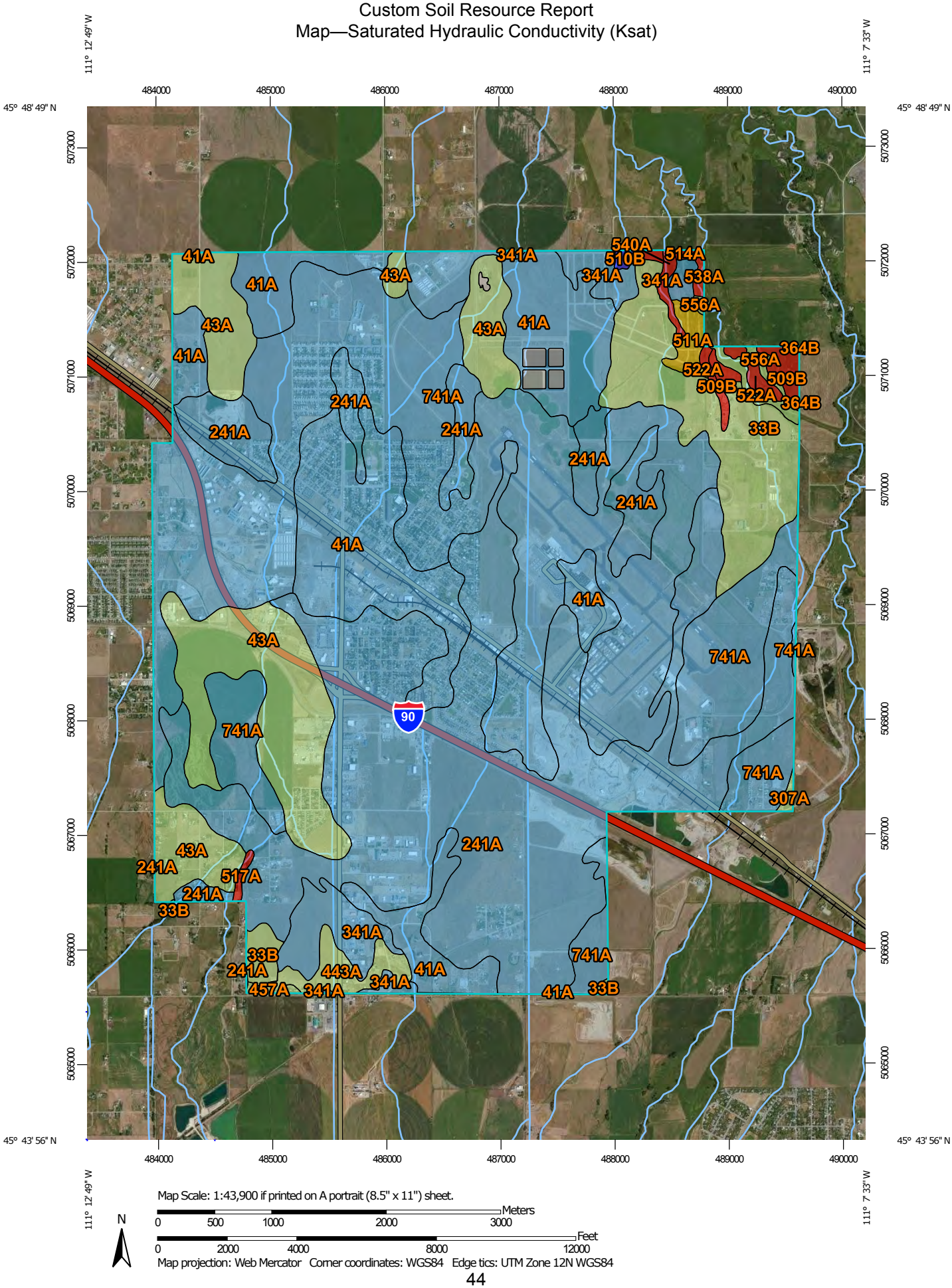
Saturated Hydraulic Conductivity (Ksat)

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity is considered in the design of soil drainage systems and septic tank absorption fields.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

The numeric Ksat values have been grouped according to standard Ksat class limits.

Custom Soil Resource Report
Map—Saturated Hydraulic Conductivity (Ksat)



Map Scale: 1:43,900 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 500 1000 2000 3000

Feet: 0 2000 4000 8000 12000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

<= 12.5000

> 12.5000 and <= 28.1118

> 28.1118 and <= 58.8487

> 58.8487 and <= 64.1513

> 64.1513 and <= 85.4210

Not rated or not available

Soil Rating Lines

<= 12.5000

> 12.5000 and <= 28.1118

> 28.1118 and <= 58.8487

> 58.8487 and <= 64.1513

> 64.1513 and <= 85.4210

Not rated or not available

Soil Rating Points

<= 12.5000

> 12.5000 and <= 28.1118

> 28.1118 and <= 58.8487

> 58.8487 and <= 64.1513

> 64.1513 and <= 85.4210

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Gallatin County Area, Montana
Survey Area Data: Version 20, Sep 19, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 28, 2011—Aug 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Saturated Hydraulic Conductivity (Ksat)

Saturated Hydraulic Conductivity (Ksat)— Summary by Map Unit — Gallatin County Area, Montana (MT622)				
Map unit symbol	**Map unit name**	**Rating (micrometers per second)**	**Acres in AOI**	**Percent of AOI**
33B	Attewan clay loam, 0 to 4 percent slopes	53.2250	462.6	5.8%
41A	Beaverell loam, 0 to 2 percent slopes	64.1513	1,154.8	14.4%
43A	Beavwan loam, 0 to 2 percent slopes	53.3230	815.1	10.2%
241A	Beaverell cobbly loam, 0 to 2 percent slopes	64.1513	2,490.5	31.1%
307A	Sudworth silty clay loam, 0 to 2 percent slopes	50.8461	6.1	0.1%
341A	Beaverell-Beavwan loams, moderately wet, 0 to 2 percent slopes	64.1513	200.9	2.5%
364B	Straw silty clay loam, 0 to 4 percent slopes	9.0000	0.1	0.0%
443A	Beavwan loam, moderately wet, 0 to 2 percent slopes	58.4638	78.4	1.0%
457A	Turner loam, moderately wet, 0 to 2 percent slopes	55.9605	2.4	0.0%
509B	Enbar loam, 0 to 4 percent slopes	12.5000	40.6	0.5%
510B	Meadowcreek loam, 0 to 4 percent slopes	85.4210	6.2	0.1%
511A	Fairway silt loam, 0 to 2 percent slopes	28.1118	35.7	0.4%
514A	Soapcreek silty clay loam, 0 to 2 percent slopes	0.9100	7.8	0.1%
517A	Saypo silt loam, 0 to 2 percent slopes, drained	4.8967	6.8	0.1%
522A	Enbar clay loam, 0 to 2 percent slopes	9.4257	28.0	0.4%
538A	Tetonview silt loam, 0 to 2 percent slopes	4.3612	0.3	0.0%
540A	Tetonview-Newtman complex, 0 to 2 percent slopes	4.3612	23.9	0.3%
556A	Threeriv-Bonebasin loams, 0 to 2 percent slopes	58.8487	35.0	0.4%
741A	Beaverell-Beavwan complex, 0 to 2 percent slopes	64.1513	2,576.8	32.2%

Saturated Hydraulic Conductivity (Ksat)— Summary by Map Unit — Gallatin County Area, Montana (MT622)				
Map unit symbol	**Map unit name**	**Rating (micrometers per second)**	**Acres in AOI**	**Percent of AOI**
W	Water		29.3	0.4%
Totals for Area of Interest			**8,001.3**	**100.0%**

Rating Options—Saturated Hydraulic Conductivity (Ksat)

Units of Measure: micrometers per second

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Fastest

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): All Layers (Weighted Average)

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Percentage of rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves,

numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
33B—Attewan clay loam, 0 to 4 percent slopes														
Attewan	90	C	0-6	Clay loam	CL	A-6	0- 0- 0	0- 5- 10	95-98-100	90-95-100	75-88-100	60-70-80	30-33-35	10-13-15
			6-12	Gravelly sandy clay loam, clay loam	CL, SC	A-6	0- 0- 0	0- 5- 10	70-85-100	65-83-100	60-78-95	35-58-80	30-33-35	10-13-15
			12-26	Gravelly loam, clay loam, sandy clay loam	CL-ML, SC-SM	A-4	0- 0- 0	0- 5- 10	65-83-100	60-80-100	50-73-95	35-53-70	25-28-30	5-8 -10
			26-60	Very cobbly sand, very gravelly loamy sand, extremely gravelly loamy sand	GM, GP-GM	A-1	0- 0- 0	25-30-35	30-45-60	20-38-55	15-25-35	5-10- 15	—	NP

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
41A—Beaverell loam, 0 to 2 percent slopes														
Beaverell	90	B	0-7	Loam	CL-ML	A-4	0- 0- 0	0- 5- 10	95-98-100	90-95-100	80-85-90	60-65-70	25-28-30	5-8 -10
			7-20	Very cobbly clay loam, very gravelly sandy clay loam, very gravelly loam	GC, GC-GM	A-2, A-4	0- 0- 0	15-33-50	40-53-65	35-48-60	30-43-55	10-25-40	25-33-40	5-10-15
			20-24	Extremely cobbly coarse sandy loam	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	25-45-65	30-45-60	25-40-55	10-25-40	5-10- 15	0-7 -14	NP
			24-60	Very cobbly loamy coarse sand, extremely cobbly loamy coarse sand, very gravelly loamy sand	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	25-45-65	30-45-60	25-40-55	10-25-40	5-10- 15	0-7 -14	NP

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
43A—Beavwan loam, 0 to 2 percent slopes														
Beavwan	85	C	0-5	Loam	CL-ML	A-4	0- 0- 0	0- 5- 10	90-95-100	85-93-100	75-83-90	55-60-65	25-28-30	5-8 -10
			5-15	Clay loam, gravelly sandy clay loam	CL, SC	A-6	0- 0- 0	0- 8- 15	80-90-100	70-85-100	55-73-90	35-50-65	30-33-35	10-13-15
			15-22	Extremely cobbly sandy clay loam, extremely cobbly sandy loam, very gravelly sandy loam	GC-GM, SC-SM	A-2	0- 0- 0	20-38-55	35-48-60	30-43-55	20-33-45	10-18-25	20-23-25	5-8 -10
			22-28	Extremely cobbly sandy loam, very gravelly sandy loam	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	20-38-55	25-43-60	20-38-55	10-23-35	5-13- 20	20-23-25	NP-3 -5
			28-60	Extremely cobbly loamy sand, extremely cobbly sand, very gravelly coarse sand	GP, GP-GM, SP, SP-SM	A-1	0- 0- 0	20-38-55	25-43-60	20-38-55	10-20-30	0- 5- 10	—	NP

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
241A—Beaverell cobbly loam, 0 to 2 percent slopes														
Beaverell	85	B	0-7	Cobbly loam	CL-ML, SC-SM	A-4	0- 0- 0	15-23-30	80-90-100	70-80-90	55-68-80	45-58-70	20-25-30	NP-5-10
			7-20	Very cobbly clay loam, very gravelly sandy clay loam, very gravelly loam	GC, GC-GM	A-2, A-4	0- 0- 0	15-33-50	40-53-65	35-48-60	30-43-55	10-25-40	25-33-40	5-10-15
			20-24	Extremely cobbly coarse sandy loam	GP-GM, SM, SP-SM, GM	A-1	0- 0- 0	25-45-65	30-45-60	25-40-55	10-25-40	5-10- 15	20-23-25	NP-3 -5
			24-60	Extremely cobbly loamy coarse sand, very gravelly loamy sand	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	25-45-65	30-45-60	25-40-55	10-25-40	5-10- 15	20-23-25	NP-3 -5
307A—Sudworth silty clay loam, 0 to 2 percent slopes														
Sudworth	85	C	0-7	Silty clay loam	CL	A-6	0- 0- 0	0- 5- 10	90-95-100	85-93-100	80-88-95	75-83-90	30-33-35	10-13-15
			7-24	Loam, silt loam, clay loam	CL-ML	A-4	0- 0- 0	0- 0- 0	90-95-100	90-95-100	65-80-95	60-73-85	25-30-35	5-8 -10
			24-29	Loam, silt loam, clay loam	CL-ML	A-4	0- 0- 0	0- 0- 0	90-95-100	90-95-100	65-80-95	60-73-85	25-30-35	5-8 -10
			29-60	Very gravelly loamy sand, extremely gravelly sand, extremely cobbly loamy sand	GP-GM, SP-SM	A-1	0- 0- 0	5-20- 35	30-45-60	30-40-50	15-25-35	5- 8- 10	—	NP

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
341A—Beaverell-Beavwan loams, moderately wet, 0 to 2 percent slopes														
Beaverell	60	B	0-7	Loam	CL-ML	A-4	0- 0- 0	0- 5- 10	95-98-100	90-95-100	80-85-90	60-65-70	25-28-30	5-8 -10
			7-20	Very cobbly clay loam, very gravelly sandy clay loam, very gravelly loam	GC, GC-GM	A-2, A-4	0- 0- 0	15-33-50	40-53-65	35-48-60	30-43-55	10-25-40	25-33-40	5-10-15
			20-24	Extremely cobbly coarse sandy loam	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	25-45-65	30-45-60	25-40-55	10-25-40	5-10- 15	0-7 -14	NP

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
			24-60	Very cobbly loamy coarse sand, extremely cobbly loamy coarse sand, very gravelly loamy sand	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	25-45-65	30-45-60	25-40-55	10-25-40	5-10- 15	0-7 -14	NP
Beavwan	30	C	0-5	Loam	CL-ML	A-4	0- 0- 0	0- 5- 10	90-95-100	85-93-100	70-80-90	50-58-65	25-28-30	5-8 -10
			5-15	Clay loam, gravelly sandy clay loam	CL, SC	A-6	0- 0- 0	0- 8- 15	80-90-100	70-85-100	55-70-85	40-53-65	30-33-35	10-13-15
			15-23	Extremely cobbly sandy clay loam, extremely cobbly sandy loam, very gravelly sandy loam	GC-GM, GM, SC-SM, SM	A-1, A-2	0- 0- 0	20-38-55	35-48-60	30-43-55	15-30-45	10-18-25	20-25-30	NP-5-10
			23-60	Extremely cobbly loamy sand, extremely cobbly sand, very gravelly coarse sand	GP, GP-GM, SP, SP-SM	A-1	0- 0- 0	20-38-55	25-43-60	20-38-55	15-28-40	0- 5- 10	—	NP
364B—Straw silty clay loam, 0 to 4 percent slopes														
Straw	85	B	0-18	Silty clay loam	CL	A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	90-95-100	70-78-85	30-33-35	10-13-15
			18-60	Loam, silt loam, clay loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	80-90-100	60-73-85	25-30-35	5-10-15

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
443A—Beavwan loam, moderately wet, 0 to 2 percent slopes														
Beavwan	85	C	0-5	Loam	CL-ML	A-4	0- 0- 0	0- 5- 10	90-95-100	85-93-100	70-80-90	50-58-65	25-28-30	5-8 -10
			5-15	Clay loam, gravelly sandy clay loam	CL, SC	A-6	0- 0- 0	0- 8- 15	80-90-100	70-85-100	55-70-85	40-53-65	30-33-35	10-13-15
			15-23	Extremely cobbly sandy clay loam, extremely cobbly sandy loam, very gravelly sandy loam	GC-GM, GM, SC-SM, SM	A-1, A-2	0- 0- 0	20-38-55	35-48-60	30-43-55	15-30-45	10-18-25	20-25-30	NP-5-10
			23-60	Extremely cobbly loamy sand, extremely cobbly sand, very gravelly coarse sand	GP, GP-GM, SP, SP-SM	A-1	0- 0- 0	20-38-55	25-43-60	20-38-55	15-28-40	0- 5- 10	—	NP
457A—Turner loam, moderately wet, 0 to 2 percent slopes														
Turner	85	B	0-6	Loam	CL-ML	A-4	0- 0- 0	0- 5- 10	80-90-100	75-88-100	65-80-95	50-63-75	25-28-30	5-8 -10
			6-12	Clay loam, silty clay loam, gravelly loam	CL, GC, SC	A-6	0- 0- 0	0- 5- 10	65-83-100	60-80-100	55-73-90	35-53-70	30-35-40	10-15-20
			12-26	Loam, clay loam, gravelly loam	CL, GC, SC	A-6	0- 0- 0	0- 5- 10	65-83-100	60-80-100	55-75-95	40-58-75	30-35-40	10-13-15
			26-60	Extremely gravelly sand, very gravelly loamy sand, very gravelly sand	GM, GP, GP-GM	A-1	0- 0- 0	10-20-30	25-43-60	15-33-50	10-23-35	0- 8- 15	0-7 -14	NP

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
509B—Enbar loam, 0 to 4 percent slopes														
Enbar	85	C	0-22	Loam	CL-ML	A-4	0- 0- 0	0- 0- 0	80-90-100	75-88-100	60-73-85	50-63-75	20-25-30	5-8 -10
			22-49	Loam, sandy loam	CL-ML, ML	A-4	0- 0- 0	0- 0- 0	80-90-100	75-88-100	60-73-85	50-63-75	20-25-30	NP-5-10
			49-60	Very gravelly sandy loam, very gravelly loamy sand, extremely gravelly sandy loam	GM, GP-GM	A-1, A-2	0- 0- 0	0- 5- 10	25-43-60	15-33-50	10-25-40	5-18- 30	15-20-25	NP-3 -5
510B—Meadowcreek loam, 0 to 4 percent slopes														
Meadowcreek	85	C	0-11	Loam	CL-ML	A-4	0- 0- 0	0- 0- 0	95-98-100	90-95-100	70-83-95	50-63-75	20-25-30	5-8 -10
			11-25	Loam, sandy loam, silt loam	CL-ML, SC-SM	A-4	0- 0- 0	0- 0- 0	95-98-100	90-95-100	70-80-90	40-58-75	20-25-30	5-8 -10
			25-60	Very gravelly sand, extremely gravelly sand, very gravelly loamy sand	GP, GP-GM	A-1	0- 0- 0	0- 5- 10	25-35-45	15-25-35	10-18-25	0- 5- 10	0-0 -19	NP
511A—Fairway silt loam, 0 to 2 percent slopes														
Fairway	85	C	0-15	Silt loam	CL-ML	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	90-95-100	70-80-90	20-25-30	5-8 -10
			15-46	Silt loam, loam, silty clay loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	85-93-100	60-75-90	25-33-40	5-10-15
			46-60	Sand, gravelly loamy sand, very gravelly sand	GP-GM, SM, SP, SP-SM	A-1, A-2	0- 0- 0	0- 5- 10	40-70-100	30-65-100	20-40-60	0- 8- 15	—	NP

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
514A—Soapcreek silty clay loam, 0 to 2 percent slopes														
Soapcreek	85	D	0-15	Silty clay loam	CL	A-6, A-7	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	80-85-90	30-38-45	10-15-20
			15-46	Silty clay, silty clay loam	CL	A-6, A-7	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	85-90-95	35-43-50	15-20-25
			46-60	Stratified fine sandy loam to silty clay	CL	A-6, A-7	0- 0- 0	0- 0- 0	100-100-100	90-95-100	80-88-95	55-70-85	30-38-45	10-15-20
517A—Saypo silt loam, 0 to 2 percent slopes, drained														
Saypo	85	C	0-10	Silt loam	CL-ML	A-4	0- 0- 0	0- 0- 0	100-100-100	90-95-100	85-93-100	70-80-90	20-23-25	5-8 -10
			10-21	Silty clay loam, silt loam, clay loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	90-95-100	85-93-100	75-83-90	65-73-80	25-30-35	5-10-15
			21-60	Silt loam, silty clay loam, gravelly clay loam	CL, CL-ML, GC, GC-GM	A-4, A-6	0- 0- 0	0- 0- 0	65-80-95	60-78-95	55-73-90	45-63-80	25-30-35	5-10-15
522A—Enbar clay loam, 0 to 2 percent slopes														
Enbar	85	C	0-16	Clay loam	CL	A-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	85-90-95	70-78-85	30-35-40	10-13-15
			16-53	Loam, clay loam	CL-ML	A-4	0- 0- 0	0- 0- 0	80-90-100	75-88-100	65-78-90	55-68-80	20-25-30	5-8 -10
			53-60	Very gravelly sandy loam, very gravelly loamy sand, extremely gravelly sandy loam	GM, GP-GM	A-1, A-2	0- 0- 0	0- 5- 10	25-43-60	15-33-50	10-25-40	5-18- 30	15-20-25	NP-3 -5

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
538A—Tetonview silt loam, 0 to 2 percent slopes														
Tetonview	85	C/D	0-2	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	100-100-100	100-100-100	85-90-95	70-80-90	—	—
			2-10	Silt loam	CL-ML	A-4	0- 0- 0	0- 0- 0	95-98-100	95-98-100	85-90-95	70-80-90	25-28-30	5-8 -10
			10-36	Loam, clay loam, silt loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	95-98-100	95-98-100	75-85-95	55-70-85	25-30-35	5-10-15
			36-60	Gravelly loam, clay loam, silt loam	CL-ML	A-4	0- 0- 0	0- 0- 0	75-88-100	70-85-100	65-80-95	50-63-75	25-28-30	5-8 -10

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
540A—Tetonview-Newtman complex, 0 to 2 percent slopes														
Tetonview	50	C/D	0-2	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	100-100-100	100-100-100	85-90-95	70-80-90	—	—
			2-10	Silt loam	CL-ML	A-4	0- 0- 0	0- 0- 0	95-98-100	95-98-100	85-90-95	70-80-90	25-28-30	5-8 -10
			10-36	Loam, clay loam, silt loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	95-98-100	95-98-100	75-85-95	55-70-85	25-30-35	5-10-15
			36-60	Gravelly loam, clay loam, silt loam	CL-ML	A-4	0- 0- 0	0- 0- 0	75-88-100	70-85-100	65-80-95	50-63-75	25-28-30	5-8 -10
Newtman	40	C/D	0-9	Mucky peat	PT	A-8	0- 0- 0	0- 0- 0	100-100-100	100-100-100	85-93-100	65-78-90	—	—
			9-15	Silty clay loam, silt loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	95-98-100	95-98-100	85-93-100	65-78-90	25-30-35	5-10-15
			15-24	Silty clay loam, clay loam, loam	CL	A-6	0- 0- 0	0- 3- 5	95-98-100	95-98-100	85-93-100	65-80-95	30-33-35	10-13-15
			24-60	Very gravelly sandy clay loam, very gravelly sandy loam, cobbly loam	GC-GM, SC-SM	A-2-4	0- 0- 0	20-23-25	45-58-70	35-50-65	25-40-55	10-23-35	25-28-30	5-8 -10

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
556A—Threeriv-Bonebasin loams, 0 to 2 percent slopes														
Bonebasin	45	B/D	0-4	Muck	PT	A-8	0- 0- 0	0- 0- 0	100-100-100	100-100-100	75-85-95	55-65-75	—	—
			4-15	Loam	CL-ML	A-4	0- 0- 0	0- 0- 0	95-98-100	90-95-100	75-85-95	55-65-75	25-28-30	5-8 -10
			15-25	Stratified sandy loam to silty clay loam	CL, CL-ML, SC, SC-SM	A-2, A-4, A-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	60-75-90	30-50-70	25-30-35	5-10-15
			25-60	Very cobbly loamy coarse sand, very gravelly coarse sand, extremely cobbly loamy sand	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	10-28-45	25-43-60	20-38-55	10-25-40	5-10- 15	20-23-25	NP-3 -5
Threeriv	45	C/D	0-4	Moderately decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	100-100-100	100-100-100	75-85-95	55-65-75	—	—
			4-9	Loam	CL-ML	A-4	0- 0- 0	0- 0- 0	95-98-100	90-95-100	75-85-95	55-65-75	25-28-30	5-8 -10
			9-29	Stratified sandy loam to silty clay loam	CL, CL-ML, SC, SC-SM	A-4, A-6	0- 0- 0	0- 0- 0	90-95-100	85-93-100	60-78-95	35-53-70	25-30-35	5-10-15
			29-60	Extremely gravelly loamy sand, very cobbly loamy coarse sand, very gravelly sand	GM, GP-GM	A-1	0- 0- 0	15-25-35	35-48-60	25-40-55	20-30-40	5-10- 15	15-18-20	NP-3 -5

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
741A—Beaverell-Beavwan complex, 0 to 2 percent slopes														
Beaverell	55	B	0-7	Cobbly loam	CL-ML, SC-SM	A-4	0- 0- 0	15-23-30	80-90-100	70-80-90	55-68-80	45-58-70	20-25-30	NP-5-10
			7-20	Very cobbly clay loam, very gravelly sandy clay loam, very gravelly loam	GC, GC-GM	A-2, A-4	0- 0- 0	15-33-50	40-53-65	35-48-60	30-43-55	10-25-40	25-33-40	5-10-15
			20-24	Extremely cobbly coarse sandy loam	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	25-45-65	30-45-60	25-40-55	10-25-40	5-10- 15	20-23-25	NP-3 -5

Engineering Properties–Gallatin County Area, Montana														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
			24-60	Extremely cobbly loamy coarse sand, very gravelly loamy sand	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	25-45-65	30-45-60	25-40-55	10-25-40	5-10- 15	20-23-25	NP-3 -5
Beavwan	30	C	0-5	Loam	CL-ML	A-4	0- 0- 0	0- 5- 10	90-95-100	85-93-100	75-83-90	55-60-65	25-28-30	5-8 -10
			5-15	Clay loam, gravelly sandy clay loam	CL, SC	A-6	0- 0- 0	0- 8- 15	80-90-100	70-85-100	55-73-90	35-50-65	30-33-35	10-13-15
			15-22	Extremely cobbly sandy clay loam, extremely cobbly sandy loam, very gravelly sandy loam	GC-GM, SC-SM	A-2	0- 0- 0	20-38-55	35-48-60	30-43-55	20-33-45	10-18-25	20-23-25	5-8 -10
			22-28	Extremely cobbly sandy loam, very gravelly sandy loam	GM, GP-GM, SM, SP-SM	A-1	0- 0- 0	20-38-55	25-43-60	20-38-55	10-23-35	5-13- 20	20-23-25	NP-3 -5
			28-60	Extremely cobbly loamy sand, extremely cobbly sand, very gravelly coarse sand	GP, GP-GM, SP, SP-SM	A-1	0- 0- 0	20-38-55	25-43-60	20-38-55	10-20-30	0- 5- 10	—	NP

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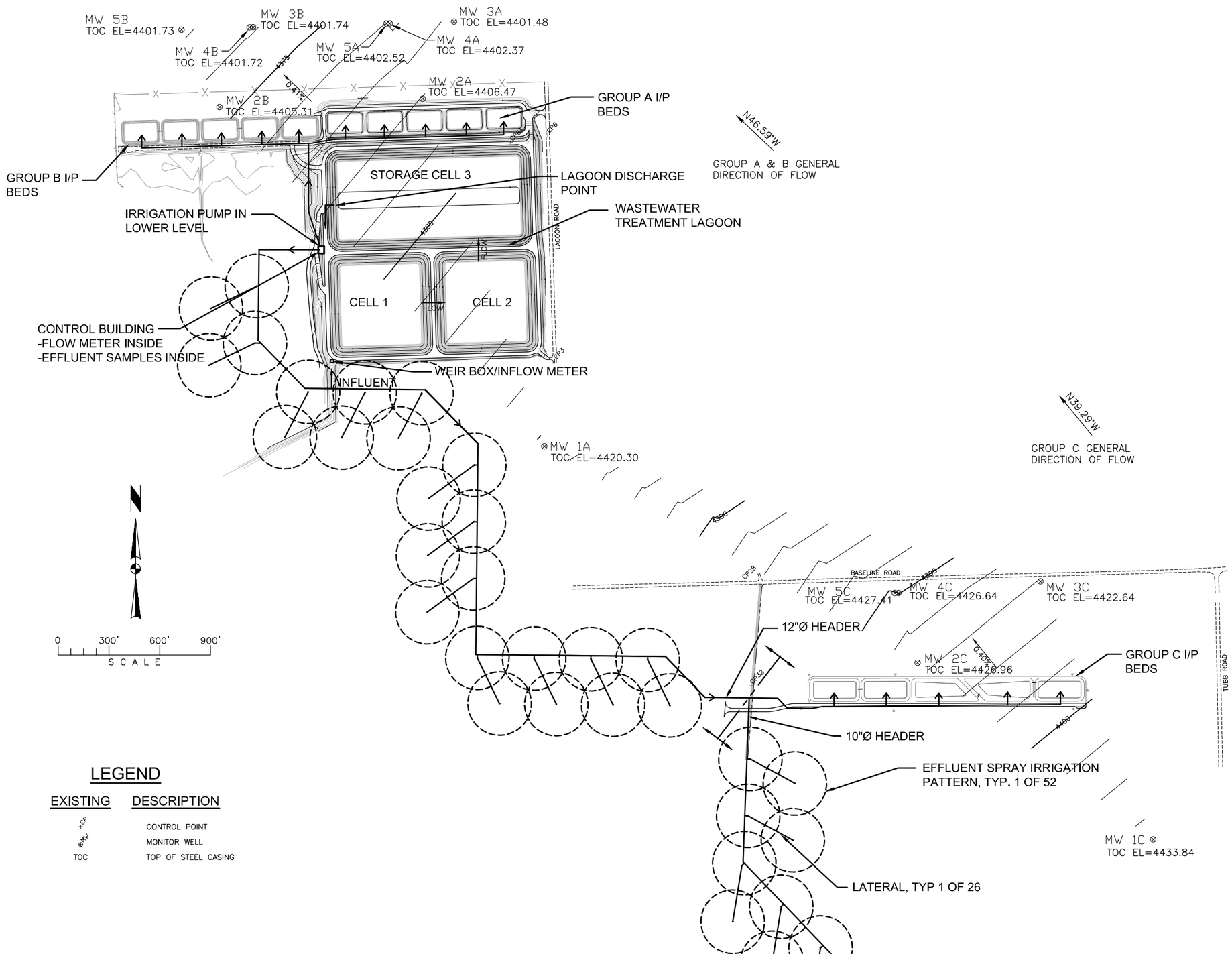
GROUNDWATER ELEVATION MAPS



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SEWER LAGOONS
BELGRADE, MONTANA

WATER TABLE ELEVATIONS 06-12-03

WELLS 06.12.03

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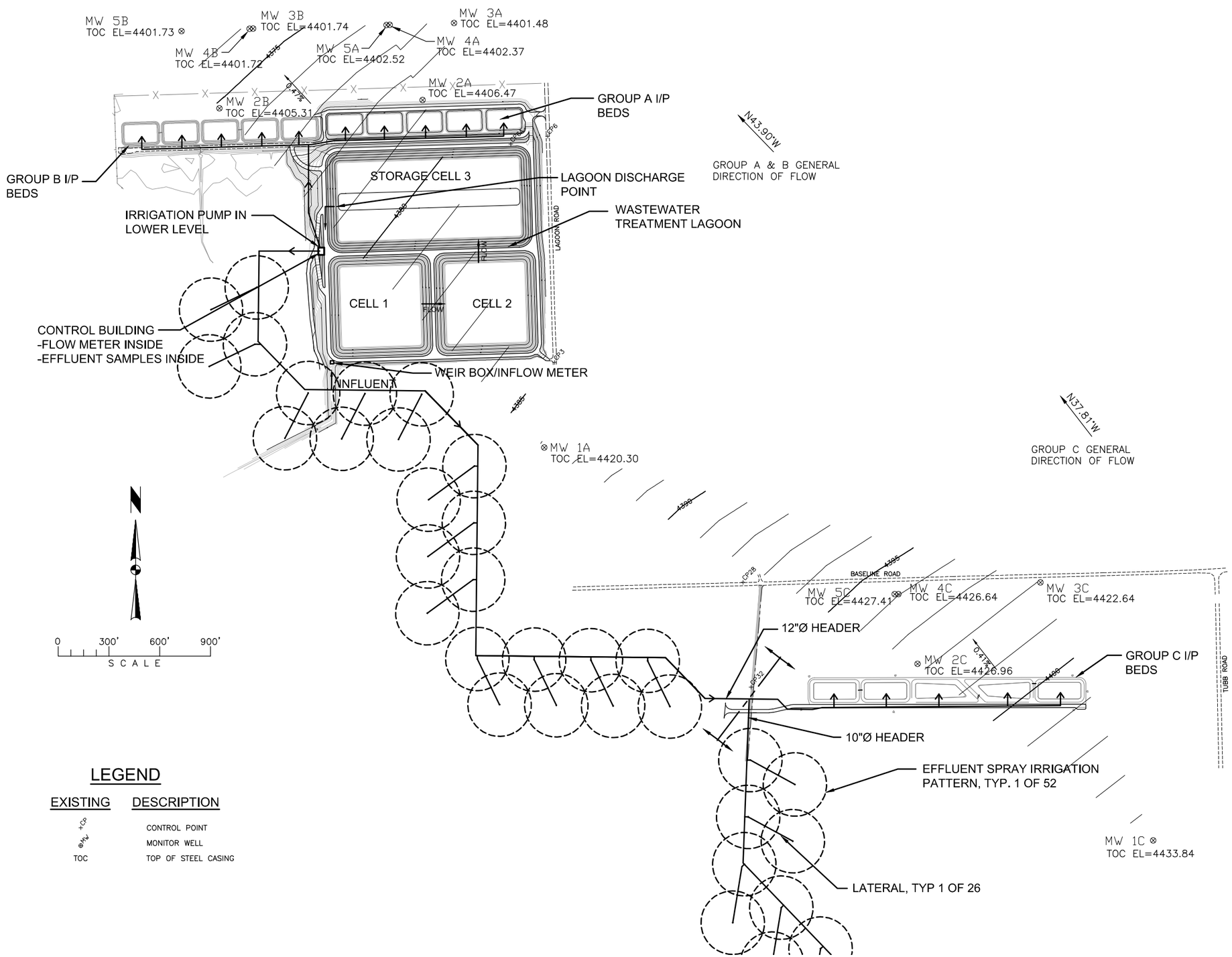

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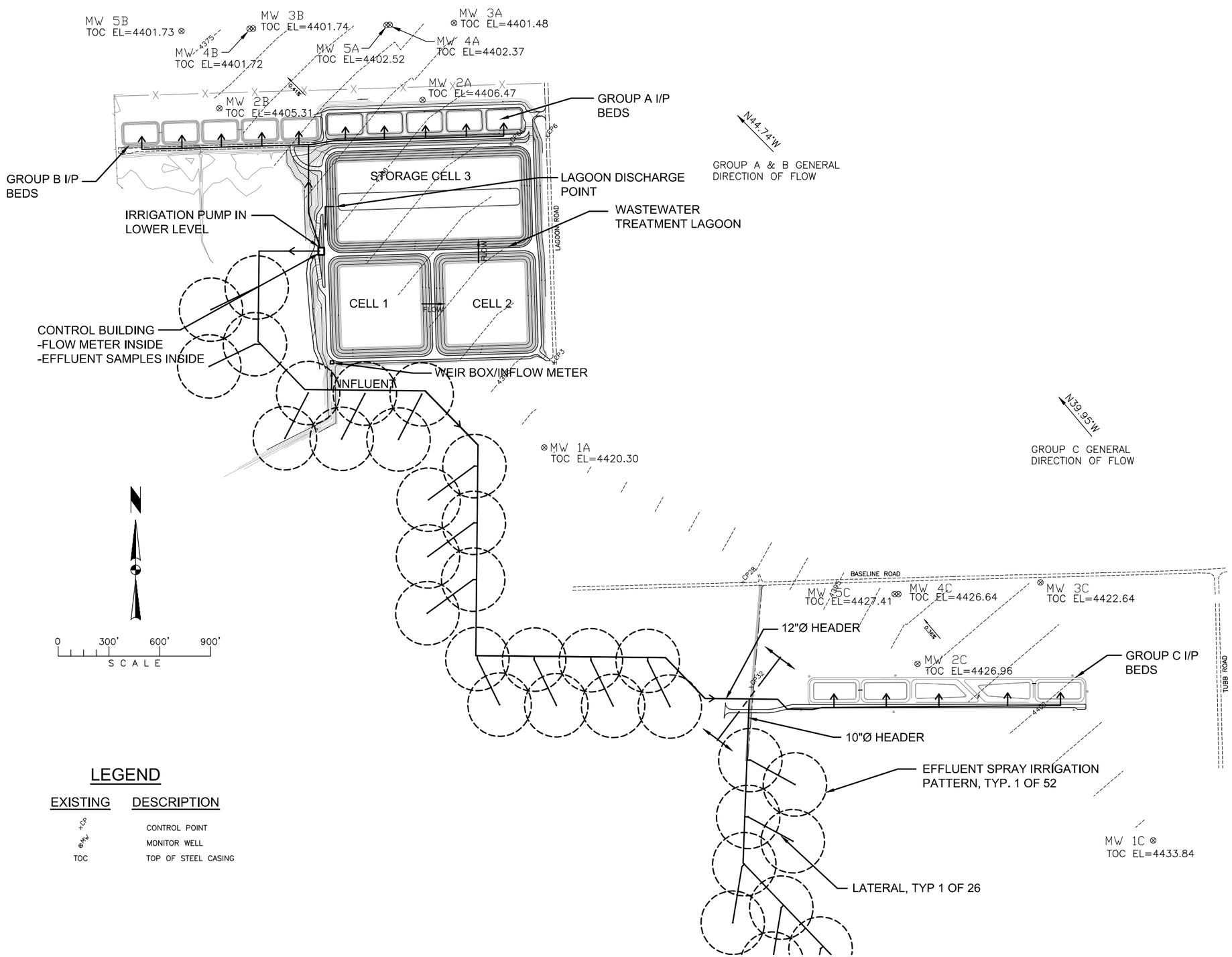

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WATER TABLE ELEVATIONS 06-16-04

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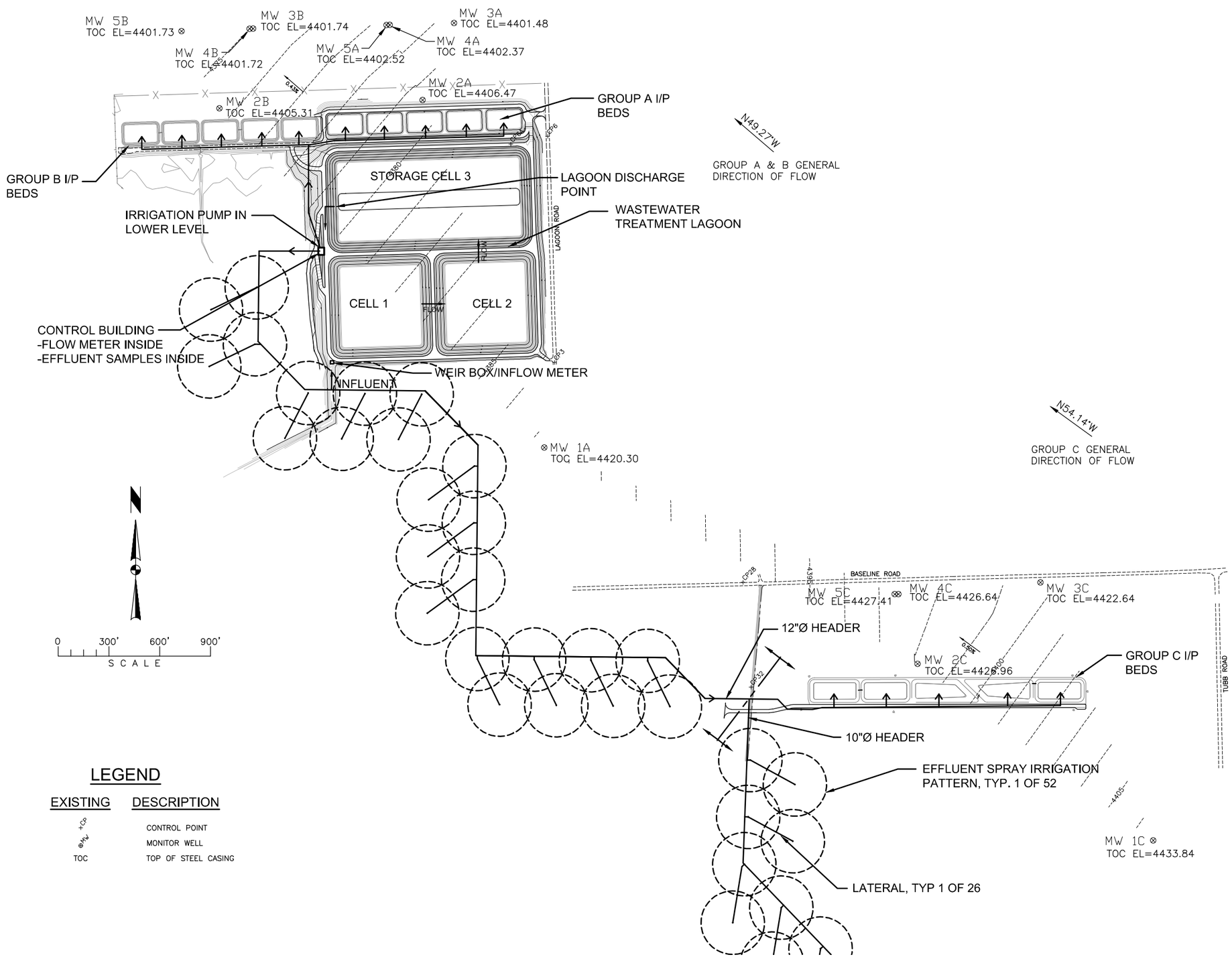

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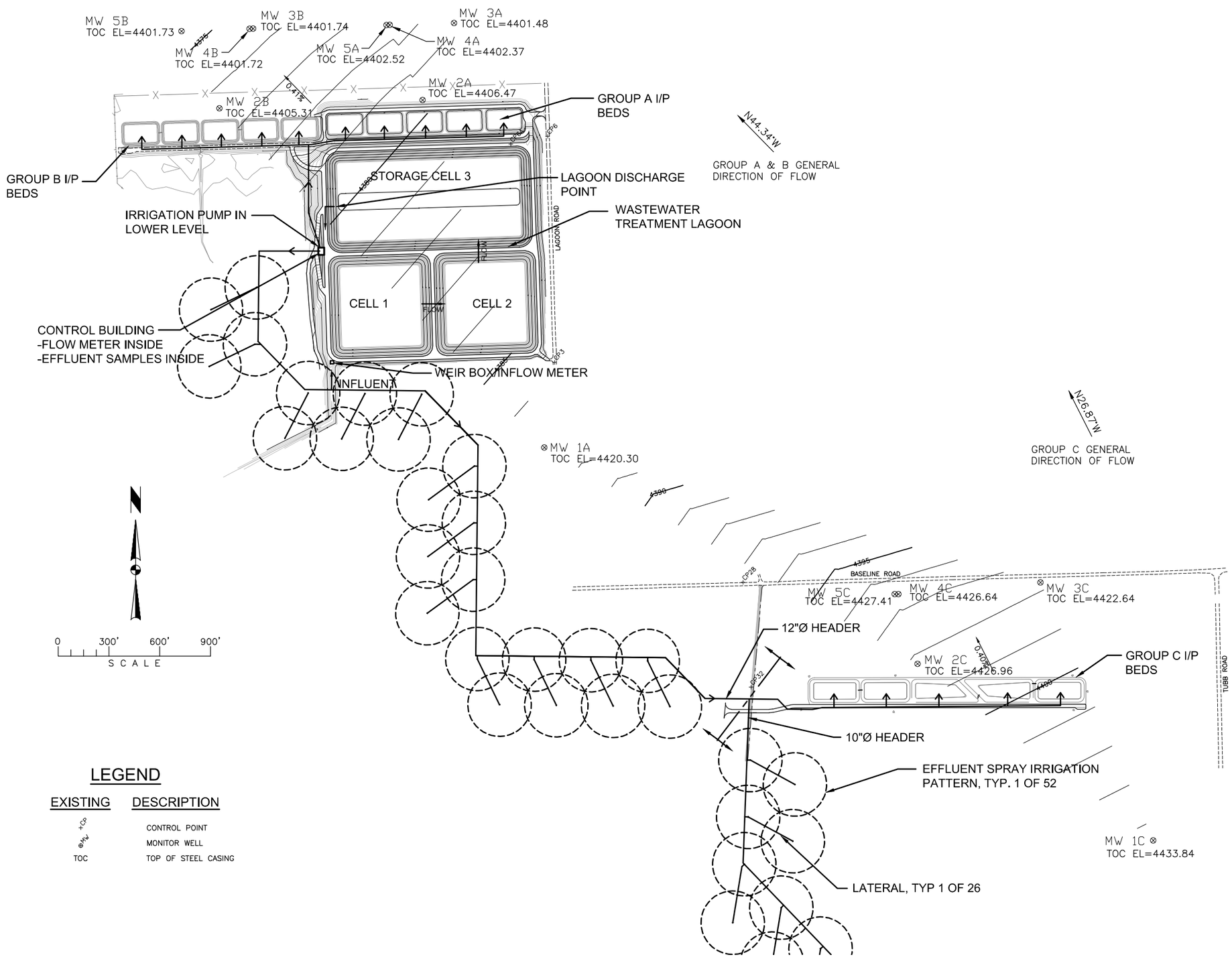

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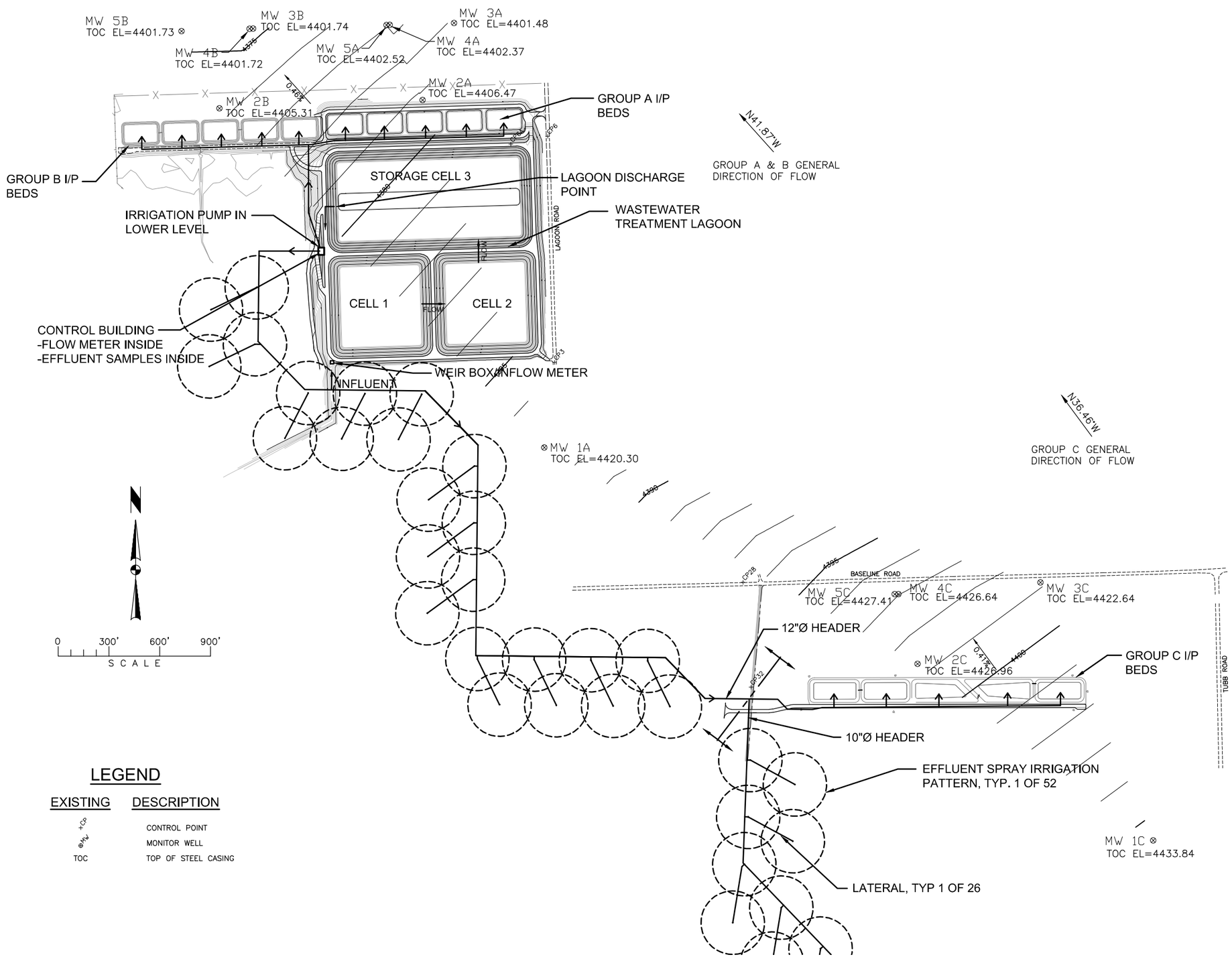

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WELLS 12.01.05

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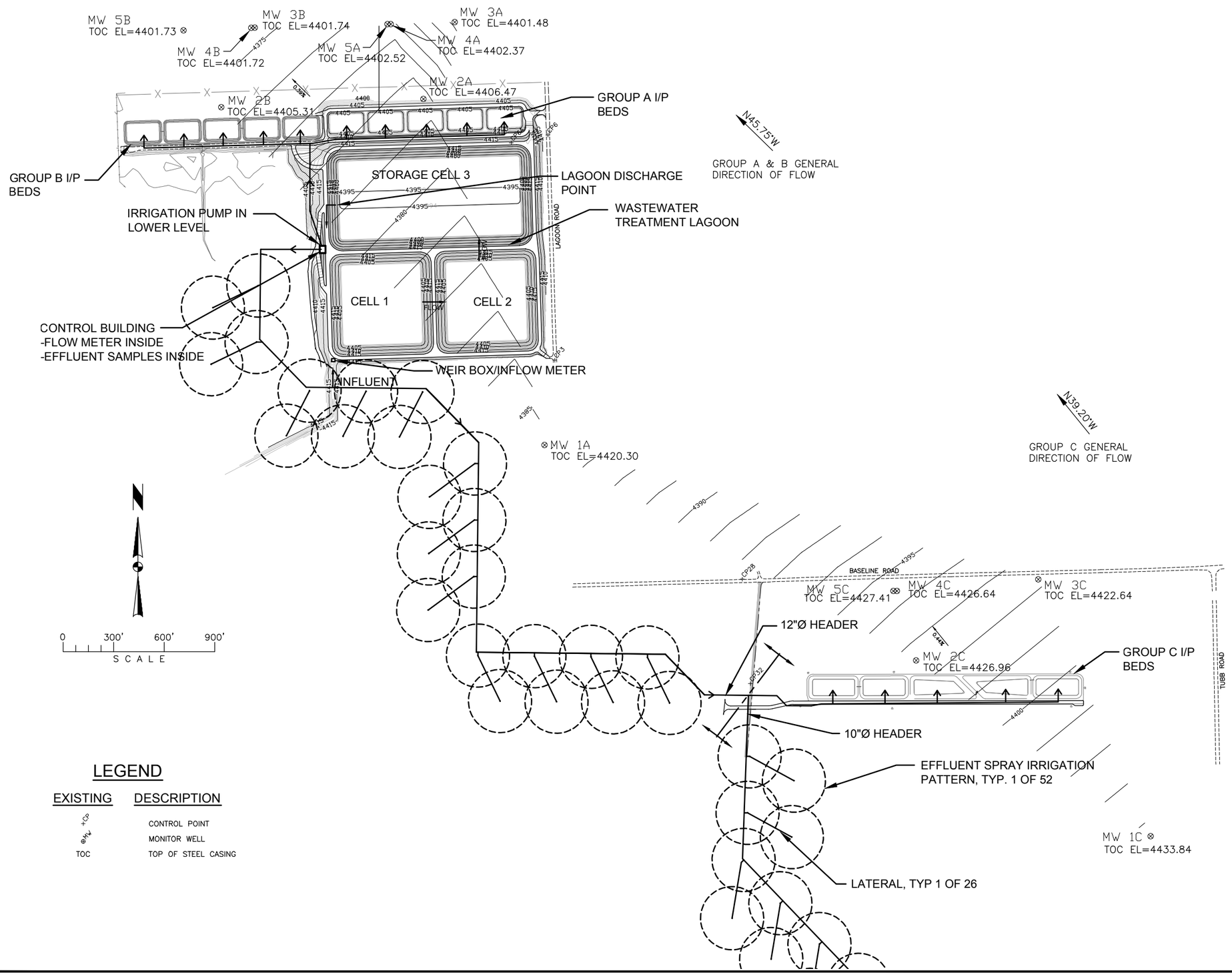

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SEWER LAGOONS
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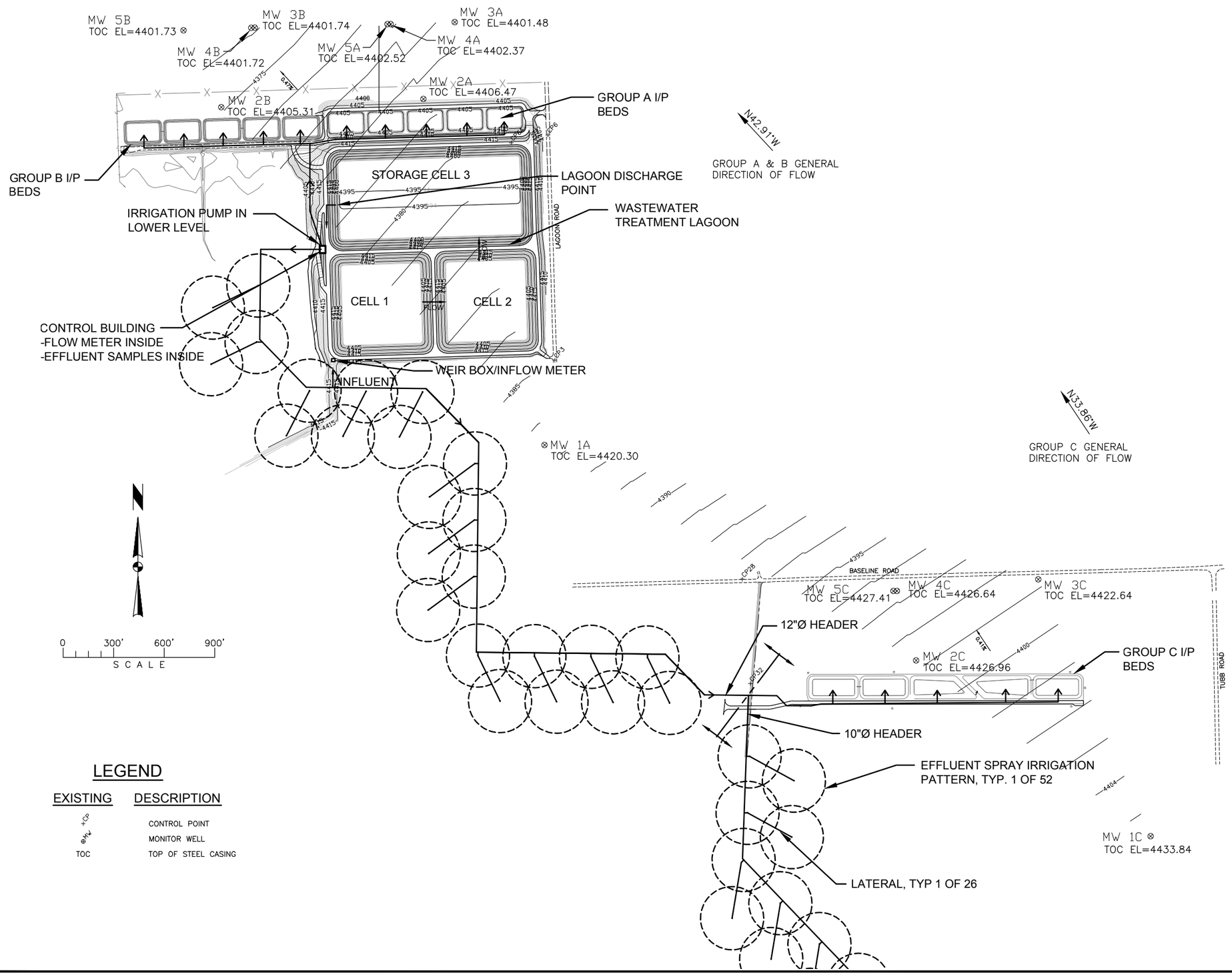

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TOC	TOP OF STEEL CASING

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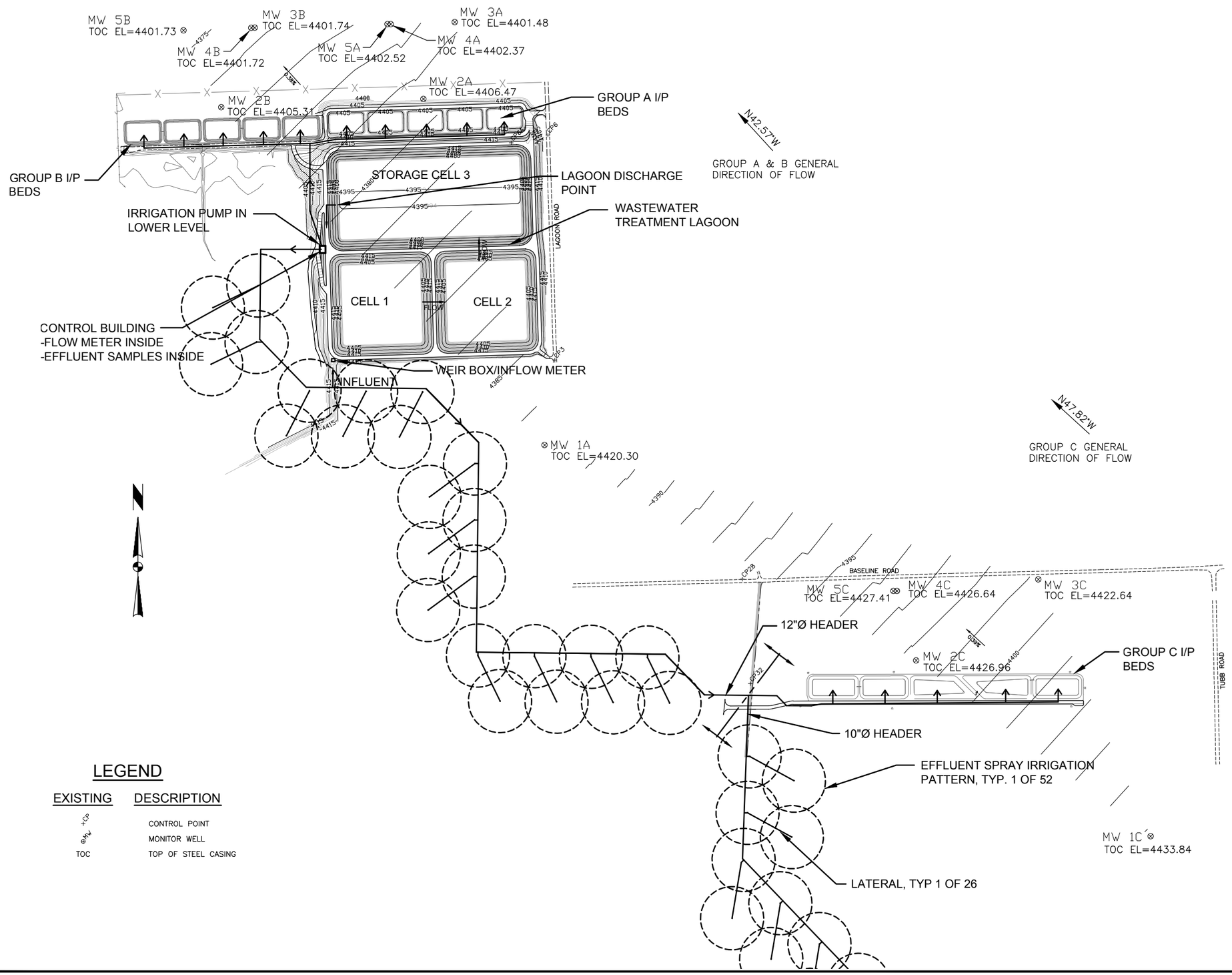

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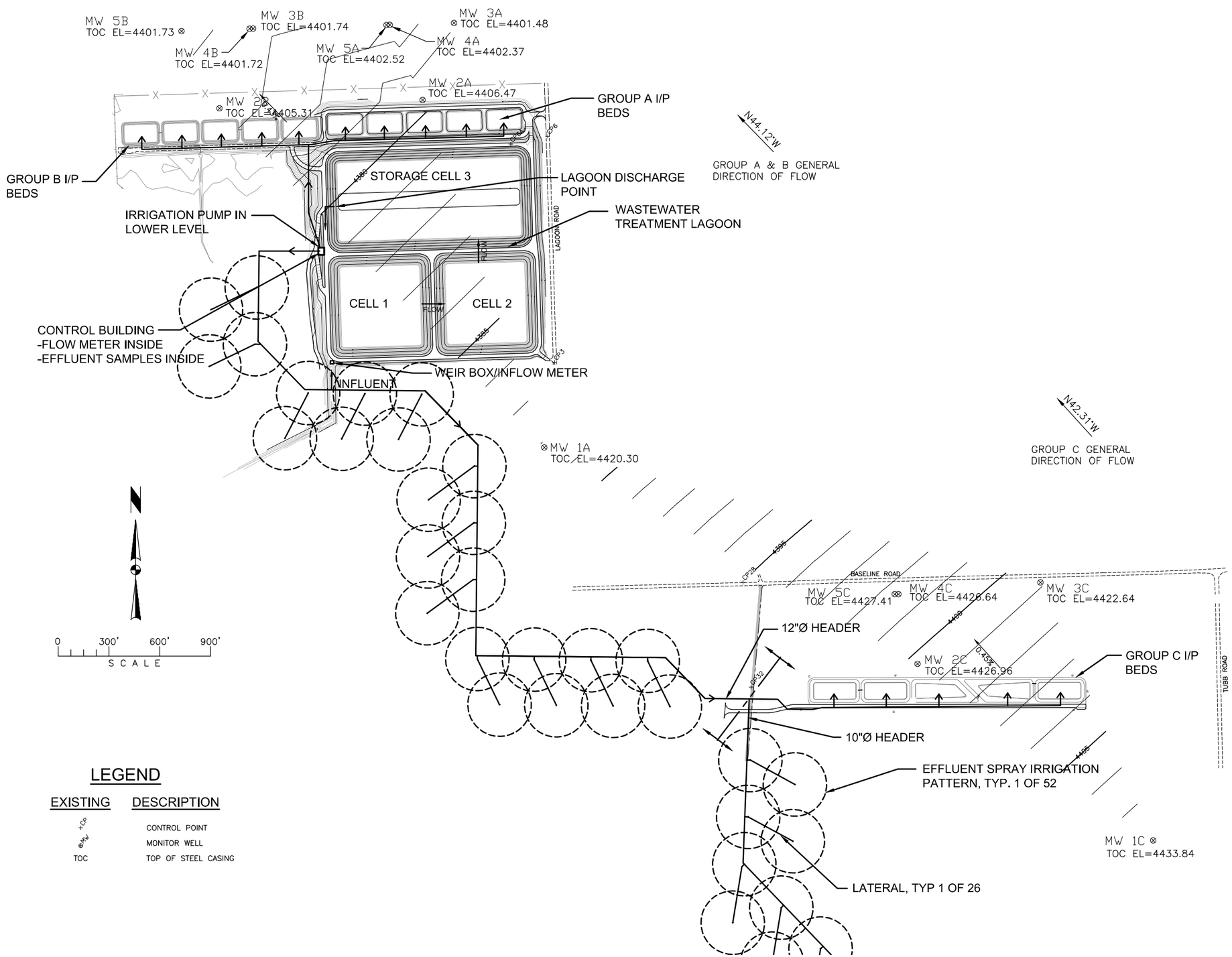

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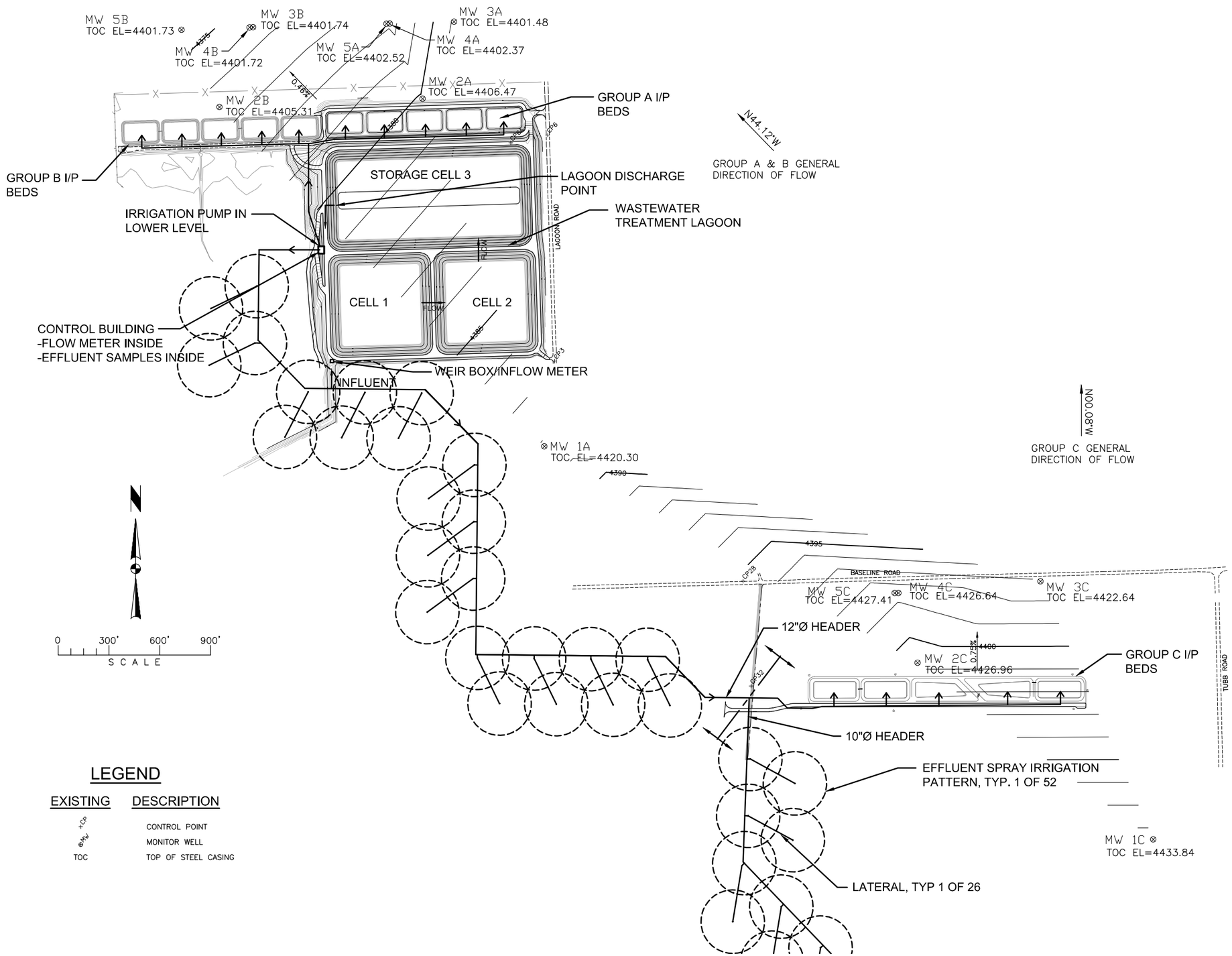

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BELGRADE, MONTANA

WATER TABLE ELEVATIONS 06-17-08

WELLS 06.17.08

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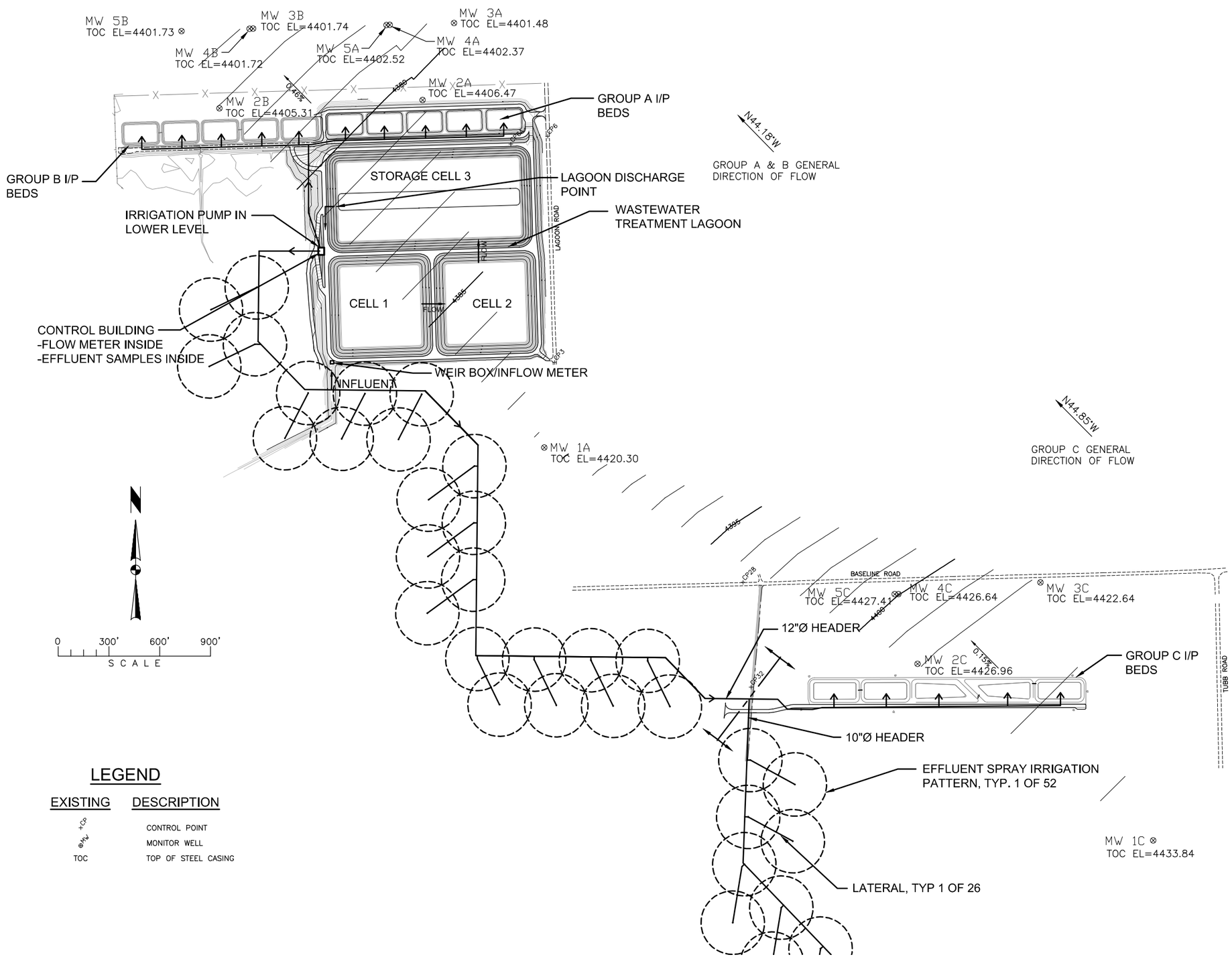

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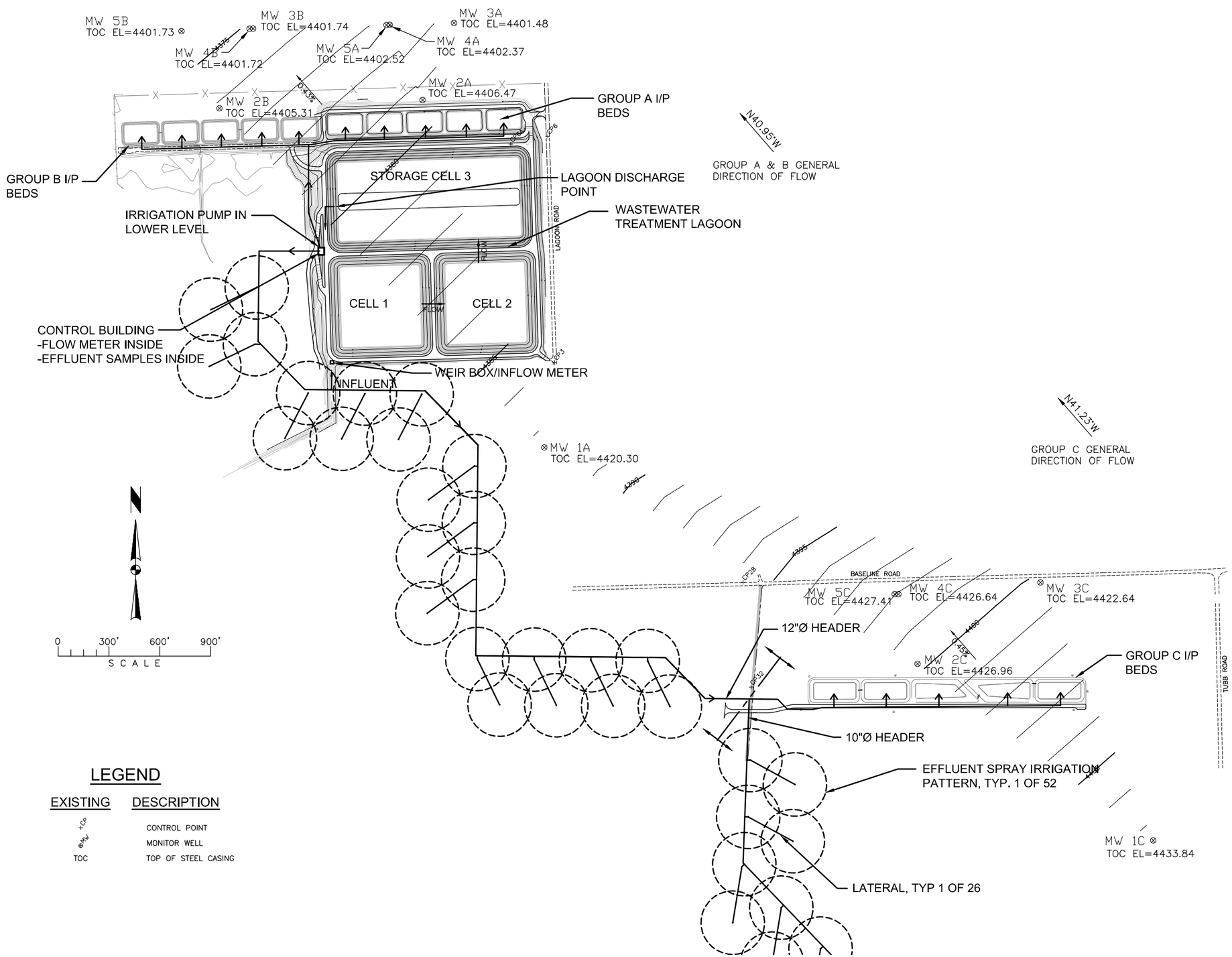

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BELGRADE, MONTANA

WATER TABLE ELEVATIONS 06-09-09

WELLS 06.09.09

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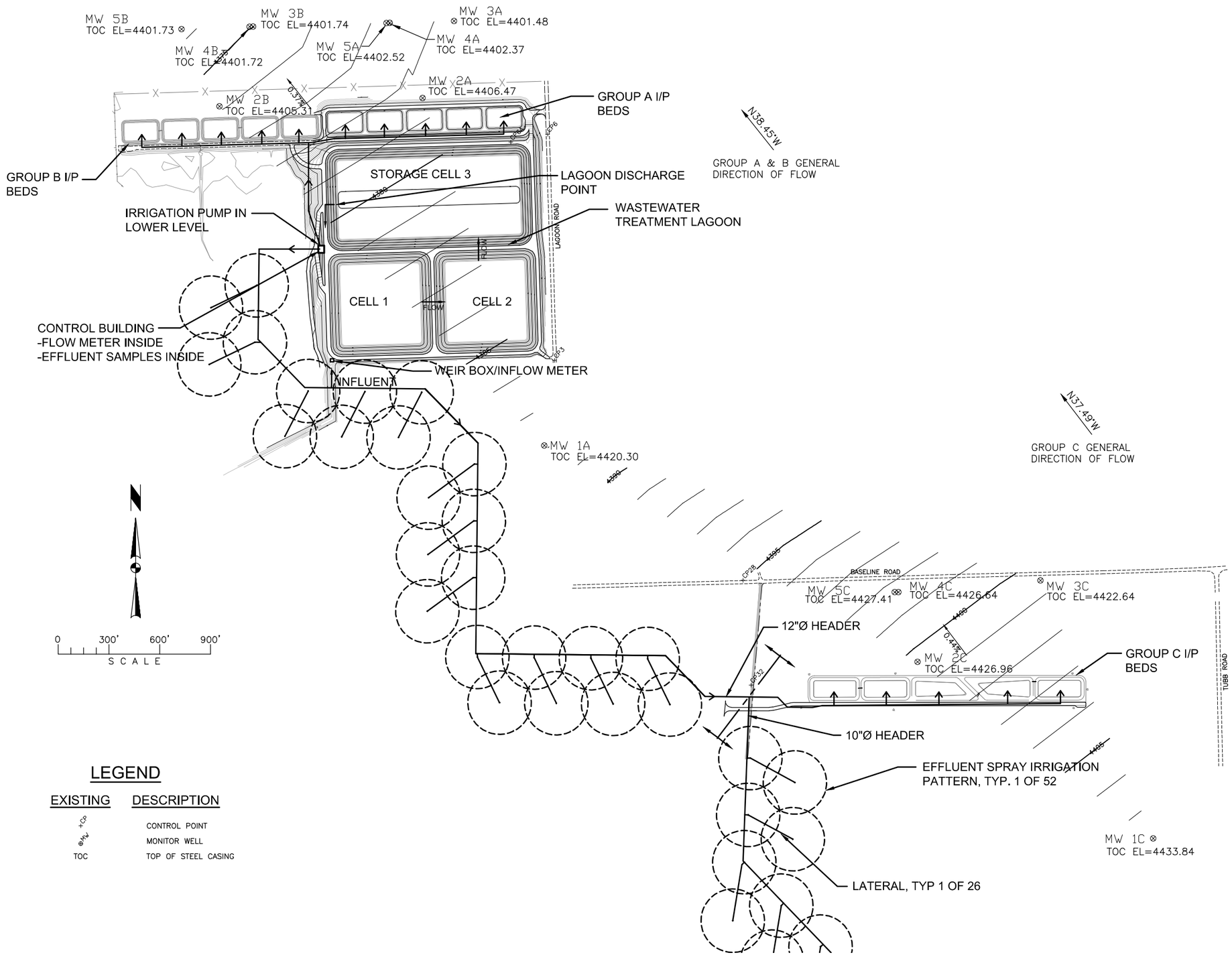

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SEWER LAGOONS
BELGRADE, MONTANA

WATER TABLE ELEVATIONS 12-15-09

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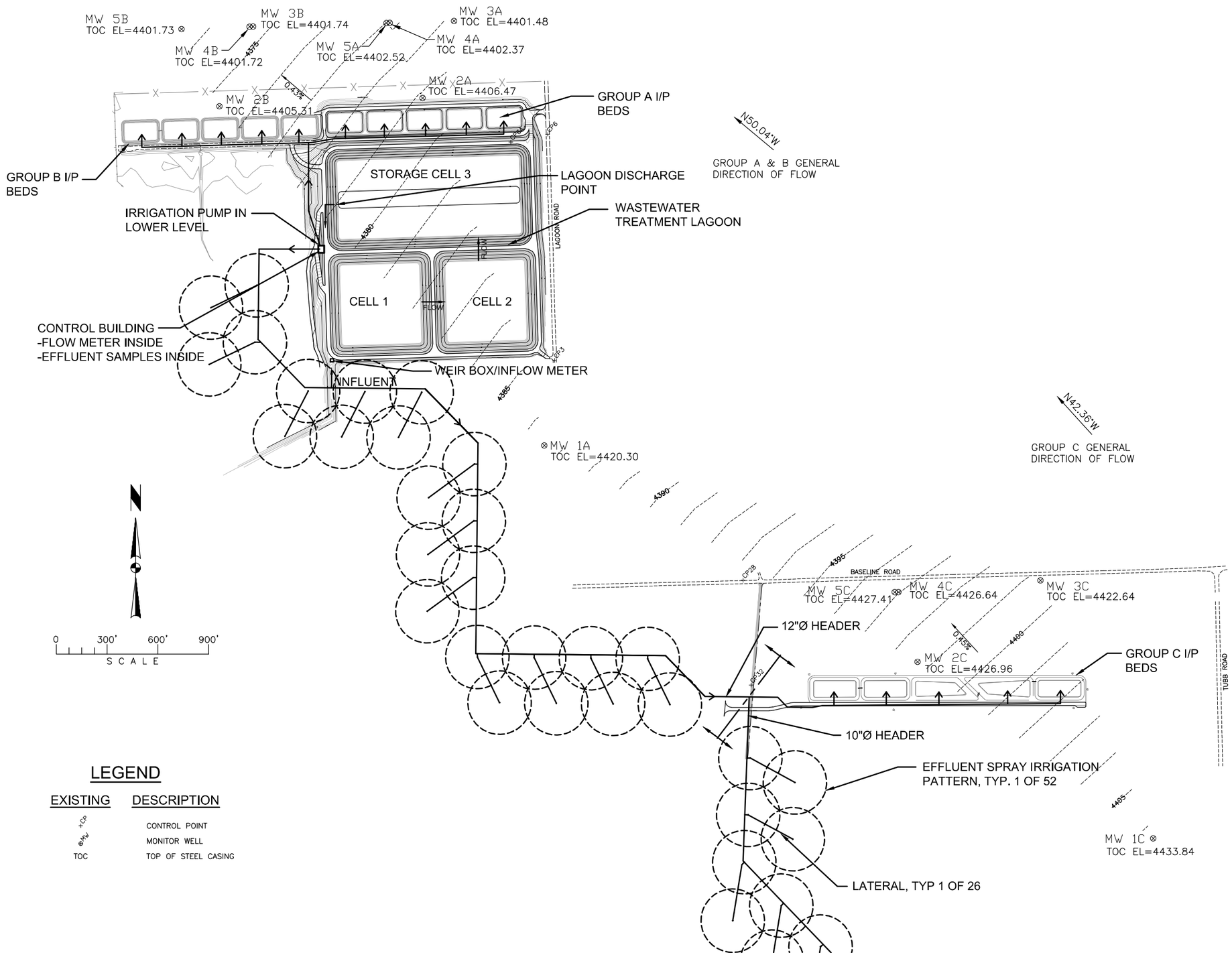

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SEWER LAGOONS
BELGRADE, MONTANA

WATER TABLE ELEVATIONS 6-8-10

WELLS 6.8.10

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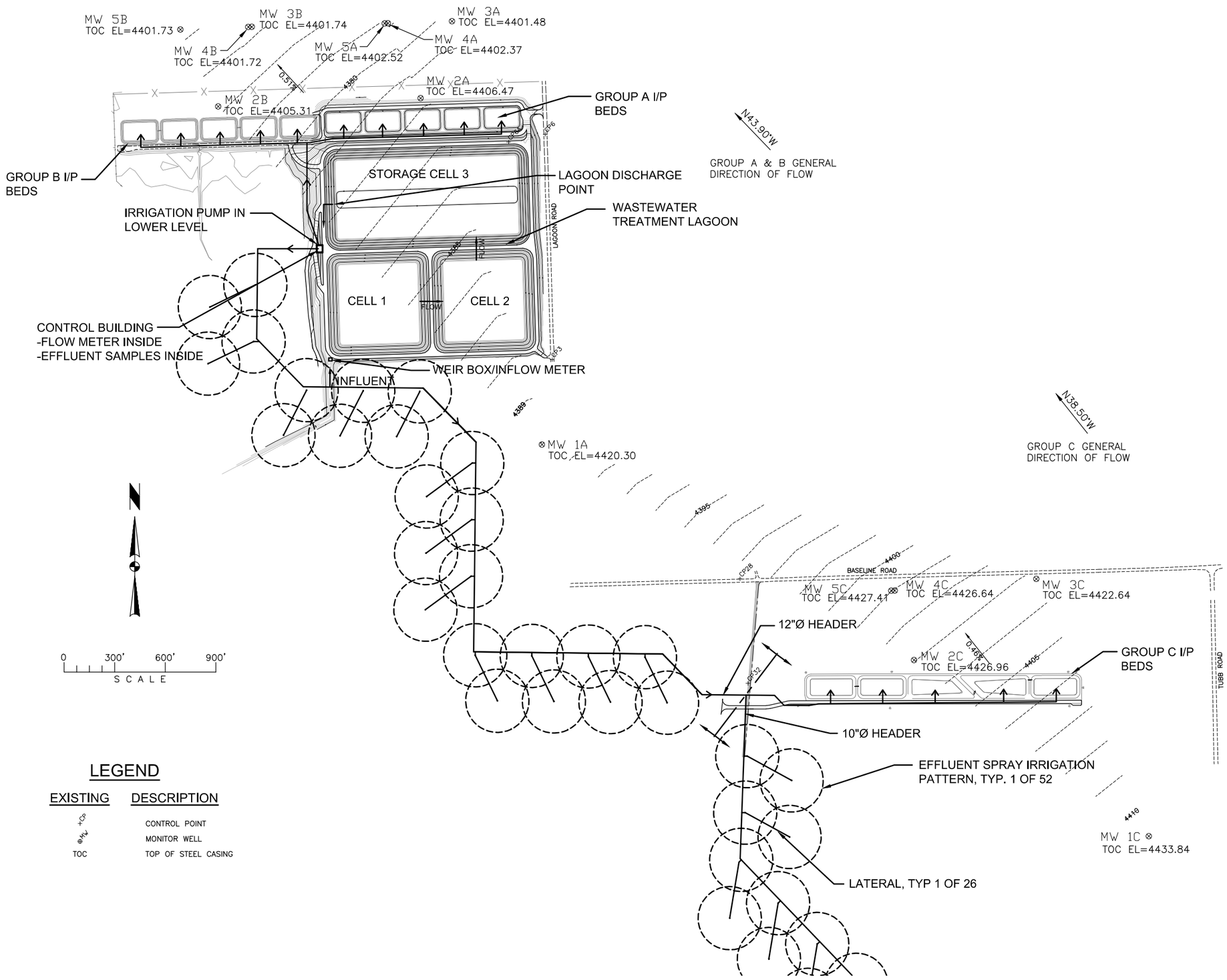

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WATER TABLE ELEVATIONS 12-2-10

WELLS 12.2.10

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FEMA MAPS

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control** structures. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 12. The horizontal datum was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for bench marks shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided in digital format by the Gallatin County GIS Department.

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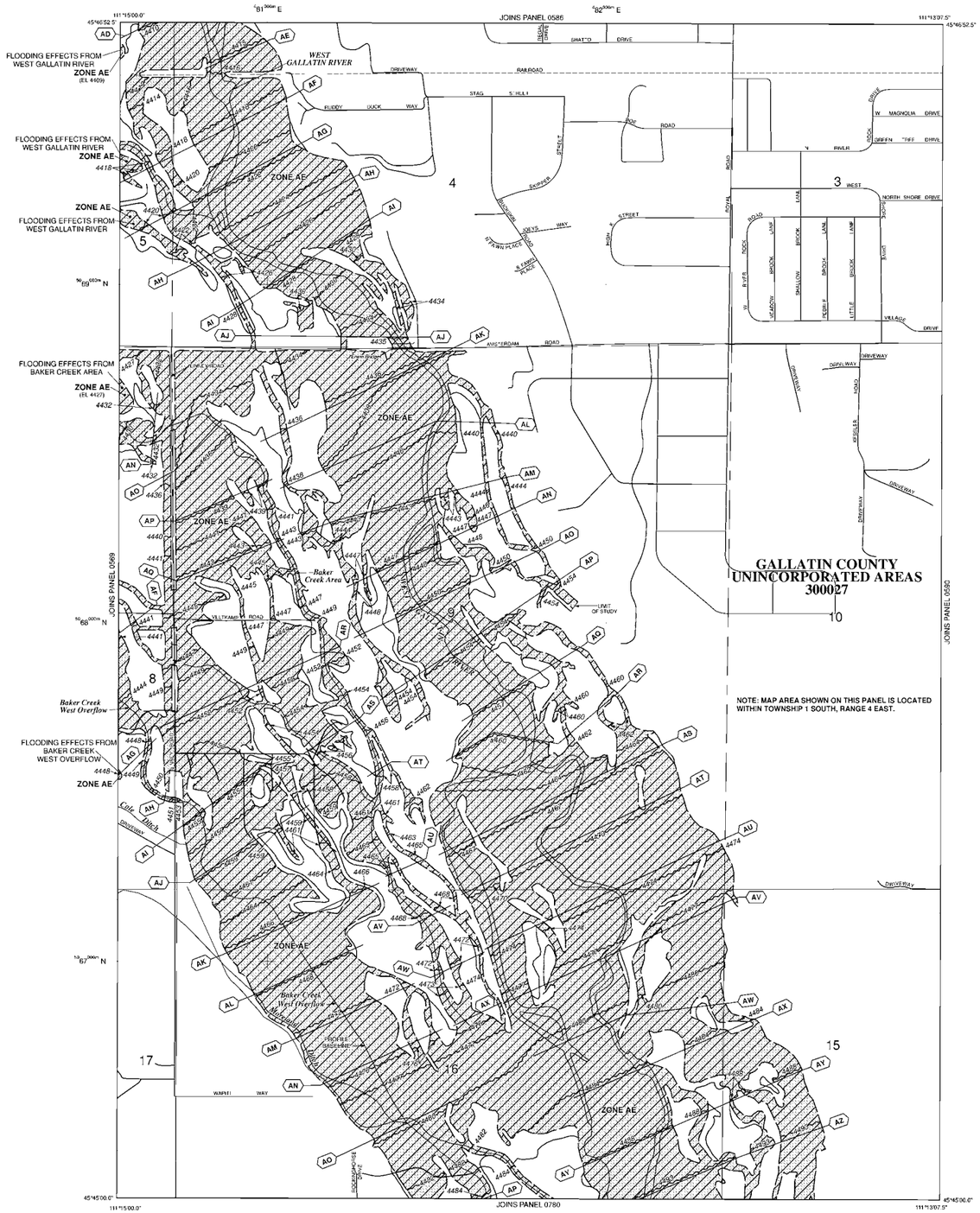
If you have **questions** about this map or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	Floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

A — A	Cross section line
23 - - - - - 23	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
4275000 N	1000-meter Universal Transverse Mercator grid ticks, zone 12
600000 M	5000-foot grid ticks: Alabama State Plane coordinate system, east zone (FIPSZONE 0101), Transverse Mercator
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
September 2, 2011
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1 800 638 6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0588D

FIRM
FLOOD INSURANCE RATE MAP
GALLATIN COUNTY, MONTANA
AND INCORPORATED AREAS

PANEL 588 OF 1725
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
GALLATIN COUNTY	30002 /	0588	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
30031C0588D

EFFECTIVE DATE
SEPTEMBER 2, 2011

Federal Emergency Management Agency

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control** structures. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 12. The horizontal datum was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for bench marks shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at http://www.ngs.noaa.gov/.

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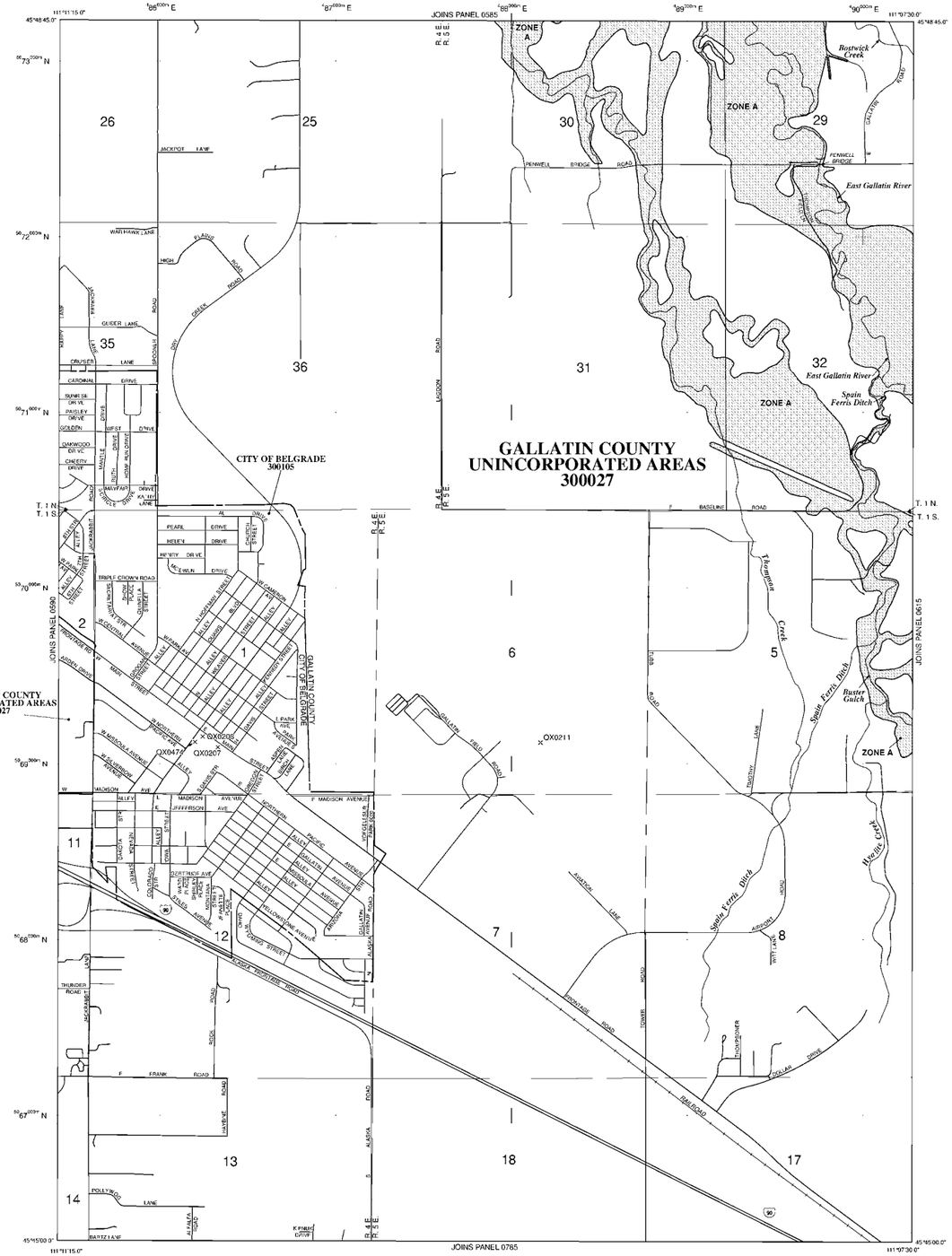

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* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

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300 0 300 600 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0595D

FIRM
FLOOD INSURANCE RATE MAP
GALLATIN COUNTY, MONTANA
AND INCORPORATED AREAS

PANEL 595 OF 1725
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
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BELGRADE, CITY OF	300105	0595	D

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MAP NUMBER
30031C0595D

EFFECTIVE DATE
SEPTEMBER 2, 2011

Federal Emergency Management Agency
~~~

POPULATION PROJECT CONFIRMATION

Nicole Rediske - Fwd: RE: Belgrade planning documents

From: Matt McGee
To: Dustin Nett; Nicole Rediske
Date: 10/24/2016 8:53 AM
Subject: Fwd: RE: Belgrade planning documents
Cc: Heather Calkins; Jen Blood; Keith Waring

Good morning,

See messages below from City planner.

Steve Klotz is out of the office this week but I am planning to get with him when he returns to gather information for lift stations and hopefully parks data will be available then too. I will schedule a call after that.

Thanks,

Matt McGee, P.E. | Civil Engineer
TD&H Engineering
234 E. Babcock Street, Suite 3 | Bozeman, MT 59715
p: 406.586.0277 | c: 307.250.0088 | d: 406.602.4089
www.tdhengineering.com

>>> Jason Karp <belgradeplanning@cityofbelgrade.net> 10/24/2016 8:44 AM >>>
In general I would agree with the findings. So it goes in Belgrade-boom, bust, and repeat.
jk

From: Matt McGee [Matt.McGee@tdhengineering.com]
Sent: Monday, October 24, 2016 7:49 AM
To: Jason Karp
Cc: Keith Waring
Subject: RE: Belgrade planning documents

Jason,

Yes, the 8,479 was a typo on page three. Thanks for catching that. Do you agree with the trends in the study? Are we able to use this moving forward with our master planning reports?

Matt McGee, P.E. | Civil Engineer
TD&H Engineering
234 E. Babcock Street, Suite 3 | Bozeman, MT 59715
p: 406.586.0277 | c: 307.250.0088 | d: 406.602.4089
www.tdhengineering.com

>>> Jason Karp <belgradeplanning@cityofbelgrade.net> 10/21/2016 2:23 PM >>>
A question on Keith's population letter: On page three in the last paragraph it states that the predicted population for 2038 is 8,479. On page four the table shown predicts a population of 19,360 in 2038. Is there a typo on page three?

Population growth was slower from 2010 to 2014, but with Meadowlark Ranch and Ryen Glenn Subdivisions cranking out houses the growth rate should picking up quite a bit.

jk

From: Matt McGee [mailto:Matt.McGee@tdhengineering.com]
Sent: Friday, October 14, 2016 10:02 AM
To: Jason Karp
Cc: Keith Waring
Subject: Belgrade planning documents

Good morning Jason,

Can you please review the attached documents for inclusion in the Master Plan reports?

Thanks for your time,

Matt McGee, P.E. | **Civil Engineer**
TD&H Engineering
234 E. Babcock Street, Suite 3 | Bozeman, MT 59715
p: 406.586.0277 | c: 307.250.0088 | d: 406.602.4089
www.tdhengineering.com

APPENDIX 3

FLOW MEASURMENT VALIDATION

M.E.T.
Automation & Controls

To: City Of Belgrade WWTP

From: Dennis Burgard
Date: 27 March 2017
Ref: Influent / Effluent Flow Verification

M.E.T. performed a flow verification at the Belgrade Waste Water Treatment Plant on 03/27/17.

We first clamped a Flexim Ultrasonic Clamp-On flowmeter onto the effluent pipes and verified the MAG meters. All three MAG meters read within 5% of the clamp-on, and all parameters are entered correctly.

IP1 Flowmeter:
Model: Danfoss MAGFLO
Verified MAG parameters
Comparison between Flexim and Danfoss within 5%
Verified local display was within 1% of MAG local display

IP2 Flowmeter:
Model: Danfoss MAGFLO
Verified MAG parameters
Comparison between Flexim and Danfoss within 5%
Verified local display was within 1% of MAG local display

Recycle Flowmeter:
Model: Danfoss MAGFLO
Verified MAG parameters
Comparison between Flexim and Danfoss within 5%
Verified local display was within 1% of MAG local display

Next we performed an inspection of the influent open channel flowmeter. The influent open channel flowmeter does not have a primary device in the flow. The flow channel is simply a 21" pipe with the top cut out and a level monitor above the flow. Velocity is calculated based on pipe parameters, and pipe slope. The level is then used to calculate flow volume.

We determined two parameters were off. The pipe ID was entered as 20.5", however our records showed the actual ID was 20.78", making this change made no noticeable flow change. However we also determined the slope to be 0.001, and a value of 0.002 was entered. When changing this value, the flowrate dropped from 721 gpm to 516 gpm

It is not ideal to have an open channel flow application without a primary device affecting the flow profile, or without a velocity sensor. However, we are confident the application is working as accurately as possible, providing the data we determined and were provided is correct.

4167 MARLIN COURT ■ EAST HELENA, MT 59635 ■ PHONE 406-227-3319
E-MAIL: met@metcontrols.com ■ WEBSITE: www.metcontrols.com

PEAKING FACTORS

1800 River Drive North
Great Falls, MT 59401

406.761.3010
tdhengineering.com

MEMORANDUM

Date:	05-21-2017	**TDH Job No.:**	B16-048
To:	FILE		
From:	NMR		
Subject:	Belgrade Peaking Factors		

The purpose of this memorandum is to provide a detailed account of wastewater peaking factors for the City of Belgrade's Wastewater Master Plan calculations. Five flow types were defined in the Master Plan, including:

- Average Day Flow
- Maximum Month Flow
- Maximum Day Flow
- Peak Hour Flow
- Peak Instantaneous Flow

Raw flow data for the treatment plant's influent was downloaded from the City's SCADA system. Average day flows (ADF) were calculated by taking the yearly average of these flow rates. The average ADF was calculated for the past three years (2014 to 2016) and defined as the City's existing ADF. Projected ADF was estimated using a wastewater production rate of 86 gpcd and population projections.

Available SCADA data was also used to determine peaking factors. Monthly ADF for 2010 to 2016 were calculated along with monthly maximum month, maximum day, peak hour and peak instantaneous flows. Next, the yearly maximum value was found. The maximum value was divided by the corresponding yearly ADF to estimate the peaking factor for that specific year. Finally, the yearly peaking factors from 2010 to 2016 were compared and the highest yearly peaking factor was used to define the system's overall peaking factor. This was done for each flow type separately.

J:\2016\B16-048 Belgrade Master Plan\HYDRAULICS\Lagoon Flows\2017.05.10 Influent Flows.xlsx

OUTFALL SEWER CAPACITY

BELGRADE SEWER MASTER PLAN
City of Belgrade
TD&H Job No. B16-048

By: CEVJ
Ckd:
Date: 3/1/2018

Blue = User Inputs
Red = Results

Outfall Sewer Capacity

Estimate the capacity of the existing outfall sewer which conveys flows to the WWTP. Utilize Manning's equation.

Inputs:

Pipe: **21" SDR 35 PVC**
Inside Diameter = **21.00 in** (1.75 ft) (use nominal diameter in calculations)
Number of Barrels = **1**
Manning's n = **0.013** (per City of Belgrade *Design Standards)*
Slope, S = **0.10%** (0.00100 ft/ft) (minimum as-constructed slope)

Single Barrel Calculations:

Condition	Depth (ft) y	Theta (rad) θ	Area (SF) A	Wetted Perimeter (ft) P	Top Width (ft) T	Hydraulic Radius (ft) R	Manning's Capacity (cfs) Q	Manning's Capacity (gpm) Q	Manning's Capacity (MGD) Q	Velocity (ft/sec) V
30% Full	0.53	2.32	0.61	2.03	1.60	0.30	0.98	440	0.63	1.62
75% Full	1.31	4.19	1.94	3.67	1.52	0.53	4.57	2,051	2.95	2.36
93.8% Full*	1.64	5.28	2.34	4.62	0.84	0.51	5.39	2,419	3.48	2.30
Full	1.75	6.28	2.41	5.50	0.00	0.44	5.01	2,249	3.24	2.08

*Depth at which maximum flow occurs in a circular section.

EAST INTERCEPTOR CAPACITY

BELGRADE SEWER MASTER PLAN
City of Belgrade
TD&H Job No. B16-048

By: CEVJ
Ckd:
Date: 2018.03.01

Blue = User Inputs
Red = Results

East Interceptor Sewer Capacity

Estimate the capacity of the existing 21 inch East Interceptor sewer. Utilize Manning's equation.

Inputs:

Pipe: **21" PVC**
Inside Diameter = **21.00 in** (1.75 ft)
Number of Barrels = **1**
Manning's n = **0.013** (per City of Belgrade *Design Standards)*
Slope, S = **0.10%** (0.00100 ft/ft) (assume DEQ minimum)

Single Barrel Calculations:

Condition	Depth (ft) y	Theta (rad) θ	Area (SF) A	Wetted Perimeter (ft) P	Top Width (ft) T	Hydraulic Radius (ft) R	Manning's Capacity (cfs) Q	Manning's Capacity (gpm) Q	Velocity (ft/sec) V
30% Full	0.53	2.32	0.61	2.03	1.60	0.30	0.98	440	1.62
75% Full	1.31	4.19	1.94	3.67	1.52	0.53	4.57	2,051	2.36
93.8% Full*	1.64	5.28	2.34	4.62	0.84	0.51	5.39	2,419	2.30
Full	1.75	6.28	2.41	5.50	0.00	0.44	5.01	2,249	2.08

*Depth at which maximum flow occurs in a circular section.

INTERSTATE 90 CROSSING

BELGRADE SEWER MASTER PLAN
City of Belgrade
TD&H Job No. B16-048

By: CEVJ
Ckd:
Date: 5/3/2017

Blue = User Inputs
Red = Results

Interstate 90 Sewer Crossing Capacity

Estimate the capacity of the existing parallel sanitary sewer crossing under I-90. Utilize Manning's equation.

Inputs:

Pipe: **12" SDR 35 PVC**
Inside Diameter = **11.78 in** (0.98 ft)
Number of Barrels = **2**
Manning's n = **0.013** (per City of Belgrade *Design Standards)*
Slope, S = **0.444%** (0.00444 ft/ft)

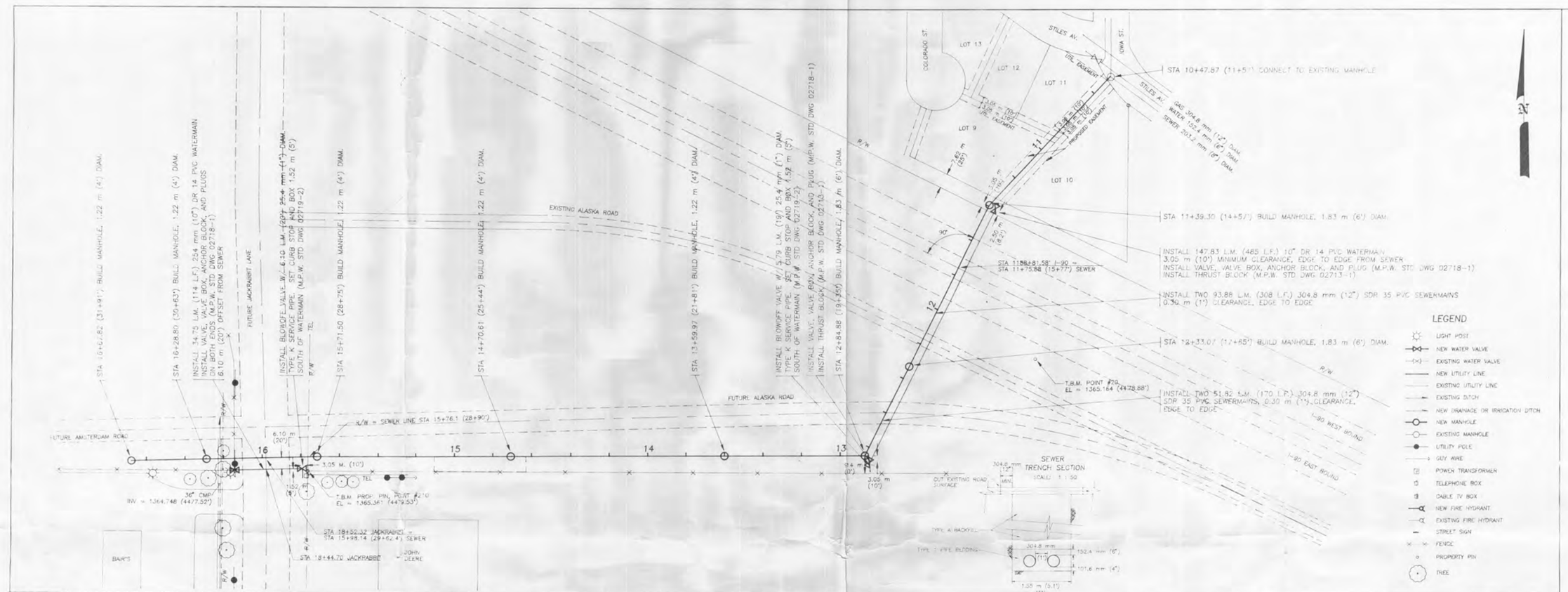
Single Barrel Calculations:

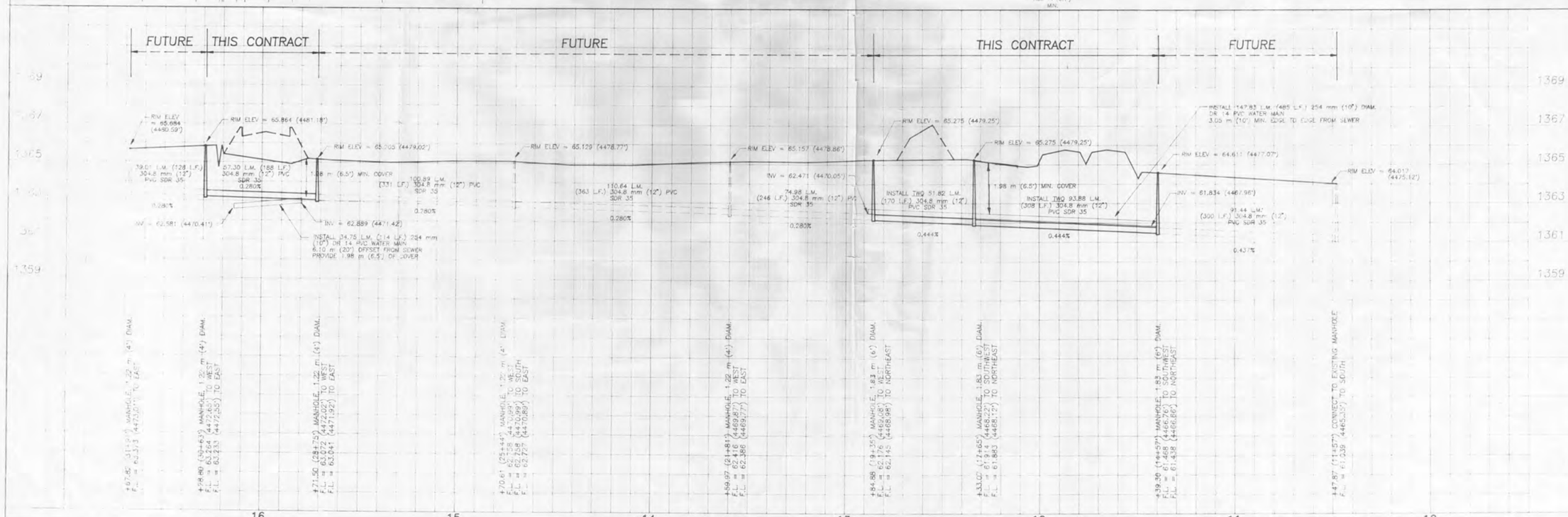
Condition	Depth (ft) y	Theta (rad) θ	Area (SF) A	Wetted Perimeter (ft) P	Top Width (ft) T	Hydraulic Radius (ft) R	Manning's Capacity (cfs) Q	Manning's Capacity (gpm) Q	Velocity (ft/sec) V
30% Full	0.29	2.32	0.19	1.14	0.90	0.17	0.44	199	2.32
75% Full	0.74	4.19	0.61	2.06	0.85	0.30	2.06	925	3.38
93.8% Full*	0.92	5.28	0.74	2.59	0.47	0.28	2.43	1,091	3.30
Full	0.98	6.28	0.76	3.08	0.00	0.25	2.26	1,014	2.99

*Depth at which maximum flow occurs in a circular section.

Crossing Capacity:

Condition	Crossing Capacity (gpm)
30% Full	**397**
75% Full	**1,850**
93.8% Full	**2,182**
Full	**2,028**





DANIELS & ASSOCIATES, INC.
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DOUGLAS E. DANIELS, P.E.
P.O. BOX 869, BELGRADE, MT 59714 (406) 388 1001

WATER & SEWER CROSSINGS
I 90 & JACKRABBIT LANE

N 1/2 of SW 1/4 SEC. 12, T. 1S., R. 4E
CITY OF BELGRADE, GALLATIN COUNTY, MONTANA

SCALE
H: 1 : 1000
V: 1 : 100

SHEET
1 of 1

REVISED 7/17/95

RV DUMP STATIONS

RV Dump Stations

Rocky Mtn Supply1.JPG

Rocky Mtn Supply2.JPG

RV Dump Stations

Town Pump1.JPG

Town Pump2.JPG

LIFT STATION INSPECTIONS

234 East Babcock Street
Suite 3
Bozeman, MT 59715

406.586.0277
tdhengineering.com

MEETING NOTES

Date:	10/20/16	**Time:**	A.M.
Present:	Dustin Nett, Wade DeBoo, Matt McGee, Dustin - City of Belgrade		
Subject:	Lift station inspections	**TDH Job No.:**	B16-048-021

Truck stop – SID #78 Lift Station

- Grease accumulation from adjacent restaurant
- False reading on probe
- Something trips one of the pumps off regularly
- City replaced pump on generator recently
- City regularly pulls pumps at all lift stations to clean and check gaskets

Farmers - #3 Lift Station

- Oil & dye regularly in wet well – may be causing issue with station
- Station only serves Gallatin Farmers Street
- Swing check valves (2) with problems – get full of rubber bands and City has to clean out. Could be old valves, may need to adjust tension in valves, pipe may be clogged from dye. One of the valves is leaking as well.
- The station can't draw down when businesses are operating
- No backup power

Jackrabbit - #1 Lift Station

- Both pumps new in 2012
- Installed bypass in 2012
- Has one trash rack, not used though
- Problems with probe – material gets on it and it breaks due to placement in turbulence
- Generator from Saddle Peak Elementary runs this station

Cruiser - #2 Lift Station

- I-beams are warped
- This station is on floats
- East pump doesn't seat properly and runs much more often than other pump
- Measure down on influent pipe is 14' 5.25" to top of pipe (12" pipe?)
- Square wet well
- Has bypass
- No generator backup

Ryen Glen Lift Station

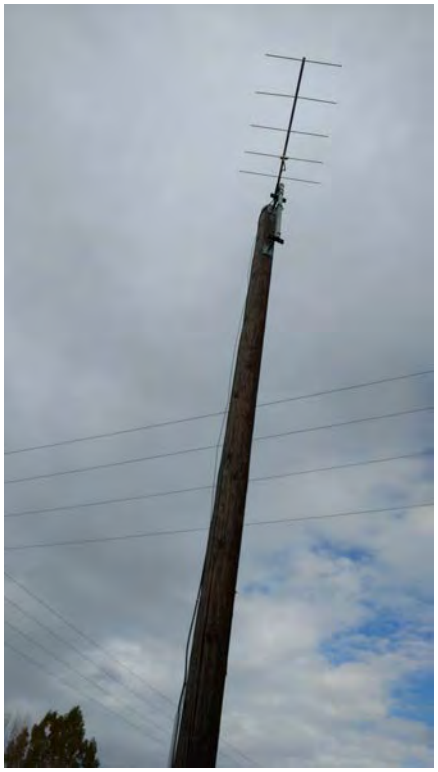
- New lift station, did not have flows for a while and still not full flows yet
- Square wet well

Meadowlark Lift Station

- Issues with probe
- Issues with electrical occasionally but fine after reset

MM to get:
- Lift station drawings
- Pretreatment ordinance
- Pump rates for each station

Jackrabbit Lift Station



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Jackrabbit Lift Station

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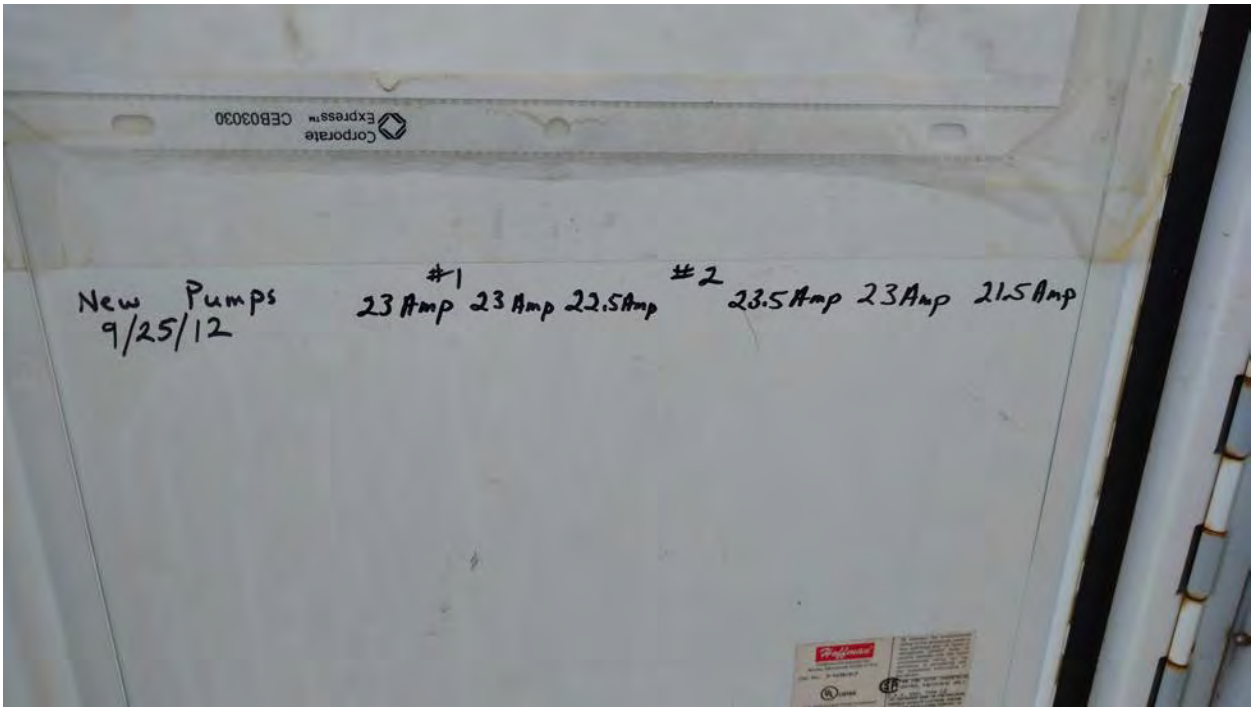

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Jackrabbit Lift Station

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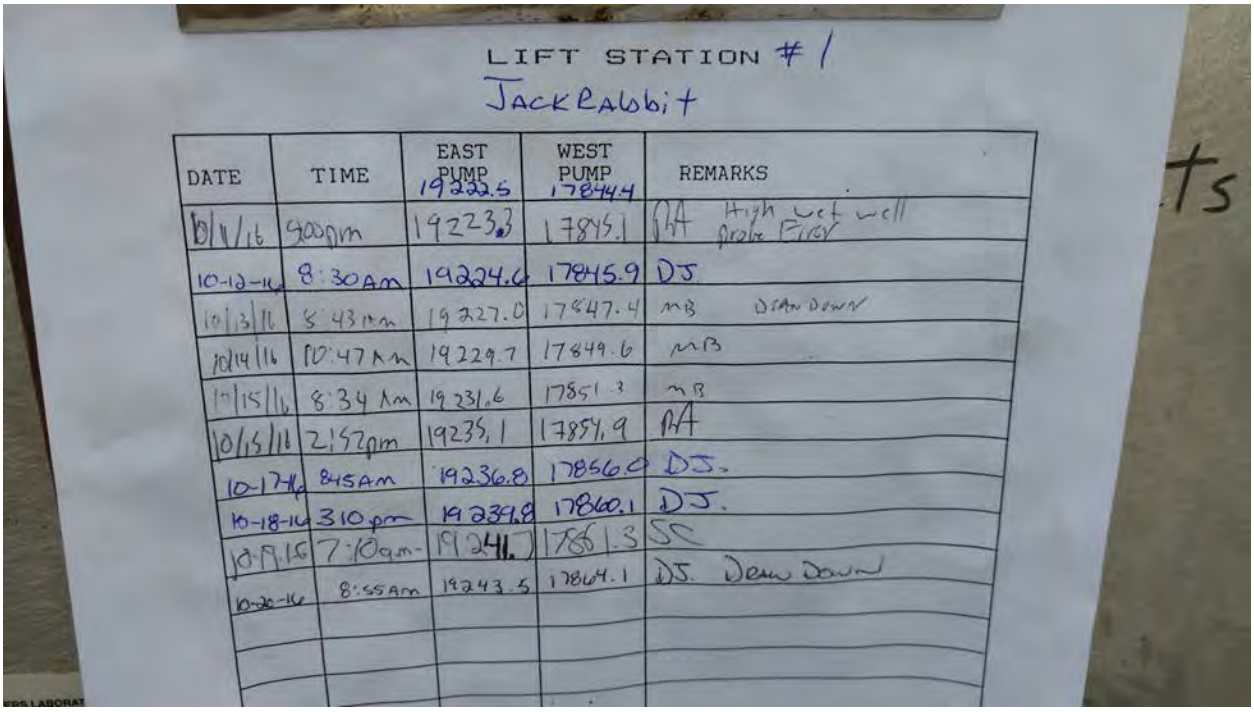

LIFT STATION #1
JackRabbit

DATE	TIME	EAST PUMP 19222.5	WEST PUMP 17844.4	REMARKS
10/11/16	900pm	19223.3	17845.1	RA High wet well probe Error
10-12-16	8:30Am	19224.6	17845.9	DJ
10/13/16	8:43Am	19227.0	17847.4	MB DRAIN DOWN
10/14/16	10:47Am	19229.7	17849.6	MB
10/15/16	8:34 Am	19231.6	17851.3	MB
10/16/16	2:52pm	19235.1	17854.9	RA
10-17-16	845Am	19236.8	17856.0	DJ.
10-18-16	310pm	19239.8	17860.1	DJ.
10-19-16	7:10am-	19241.7	17861.3	SC
10-20-16	8:55Am	19243.5	17864.1	DJ. Drain Down

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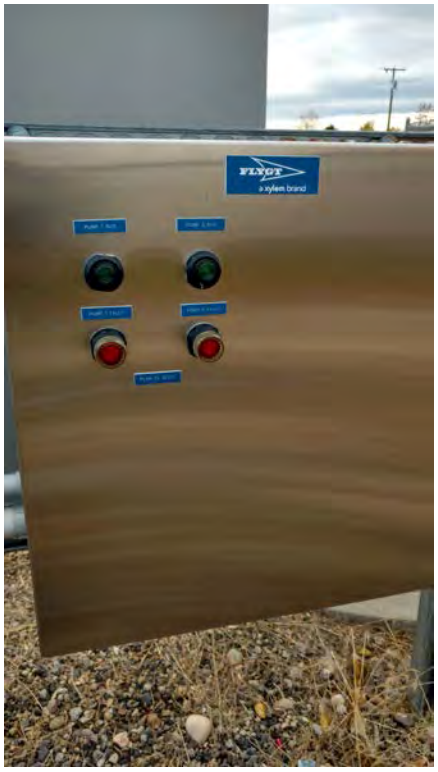
IMG_20161020_110038444_JACKRABBIT.jpg



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Jackrabbit Lift Station

IMG_20161020_110100343_HDR_JACKRABBIT.jpg

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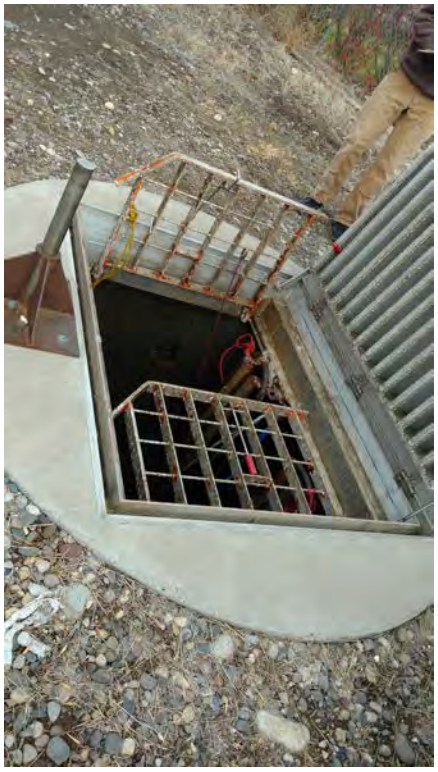
Jackrabbit Lift Station

IMG_20161020_110111127_JACKRABBIT.jpg



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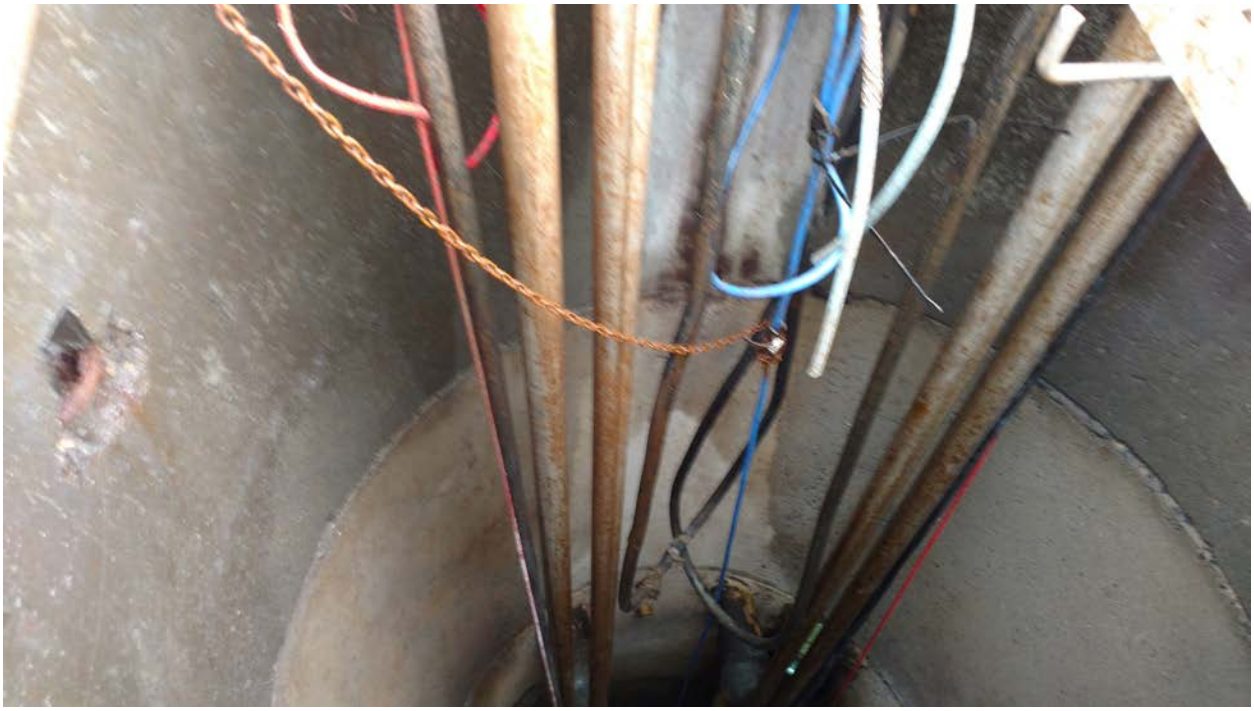

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Jackrabbit Lift Station

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Jackrabbit Lift Station

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Jackrabbit Lift Station

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Jackrabbit Lift Station

IMG_20161020_110703958_JACKRABBIT.jpg

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Cruiser Lift Station

IMG_20161020_111627275_CRUISER.jpg

IMG_20161020_111638727_CRUISER.jpg

Cruiser Lift Station

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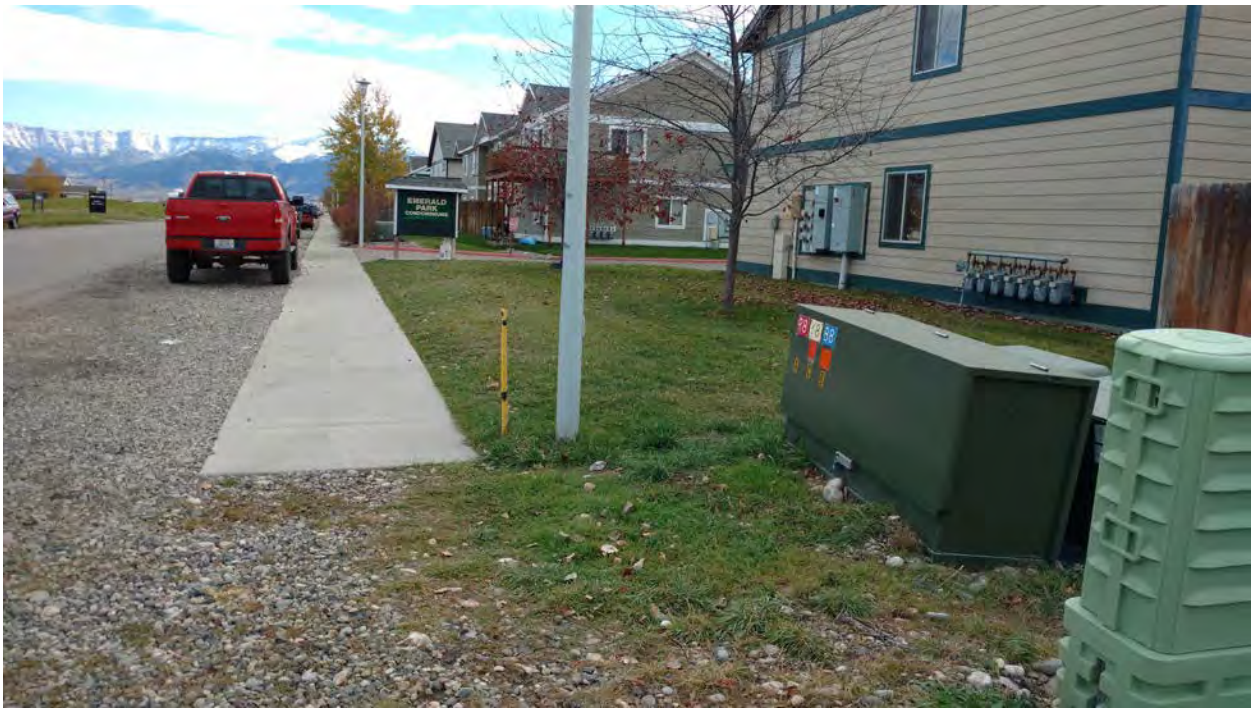
Cruiser Lift Station



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Cruiser Lift Station

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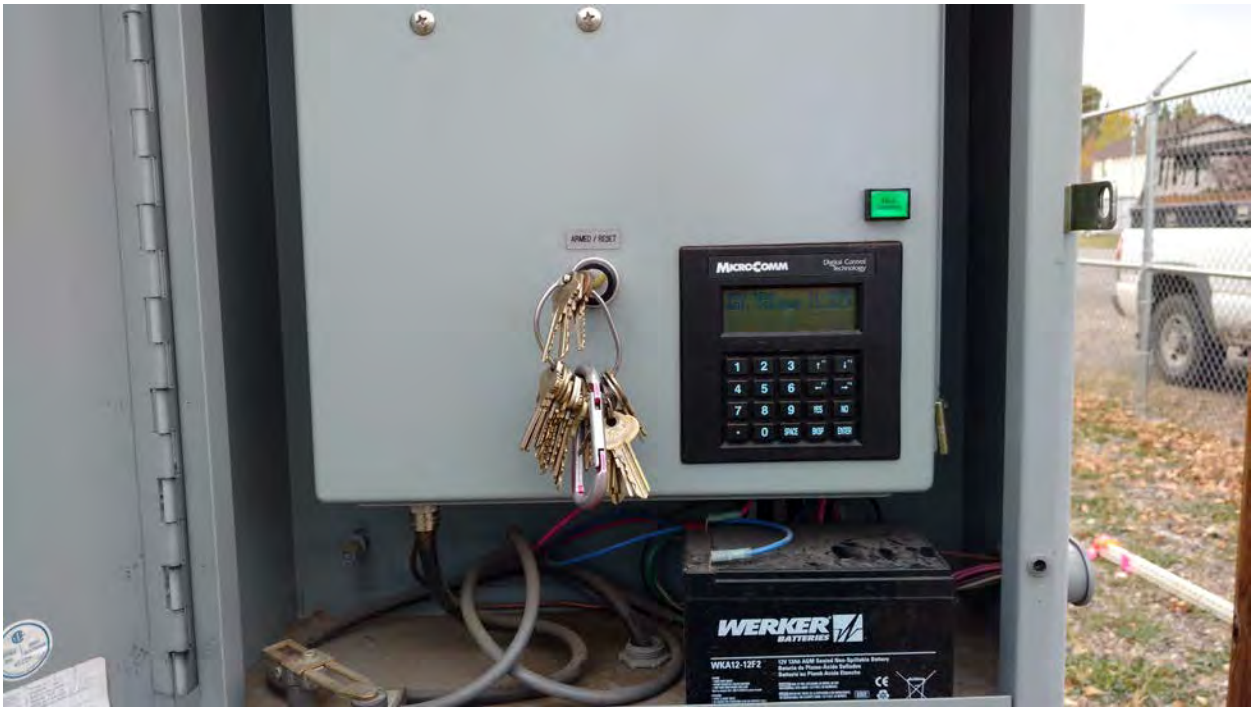

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Cruiser Lift Station

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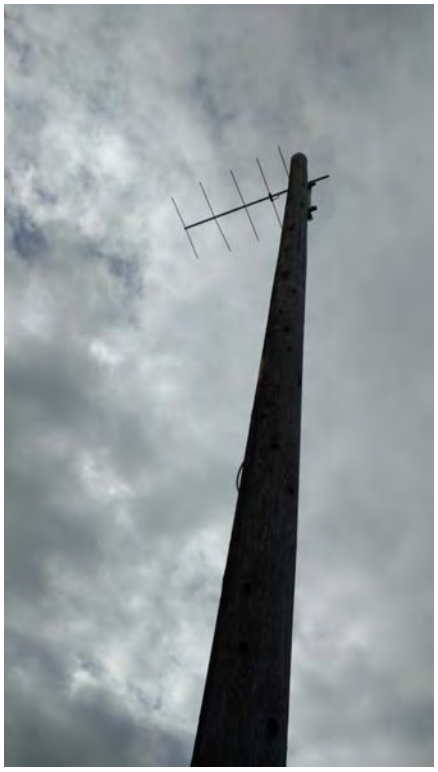

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Cruiser Lift Station

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Cruiser Lift Station

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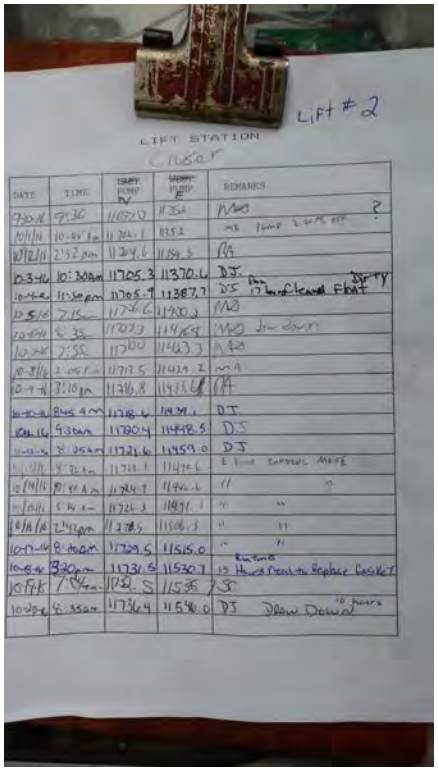

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Cruiser Lift Station

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Cruiser Lift Station

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Cruiser Lift Station

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Cruiser Lift Station

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Cruiser Lift Station

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Cruiser Lift Station

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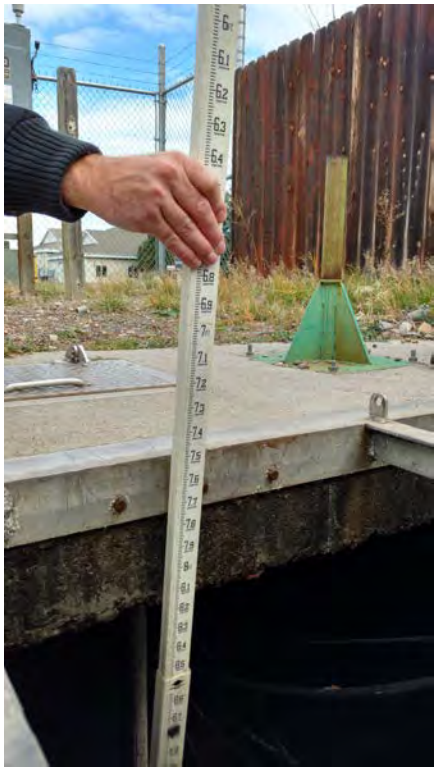

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Cruiser Lift Station

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Cruiser Lift Station

IMG_20161020_112224339_CRUISER.jpg

IMG_7063.JPG

Cruiser Lift Station

IMG_7064.JPG

IMG_7065.JPG

IMG_20161020_103639415_HDR_FARMERS.jpg

IMG_20161020_103648381_HDR_FARMERS.jpg

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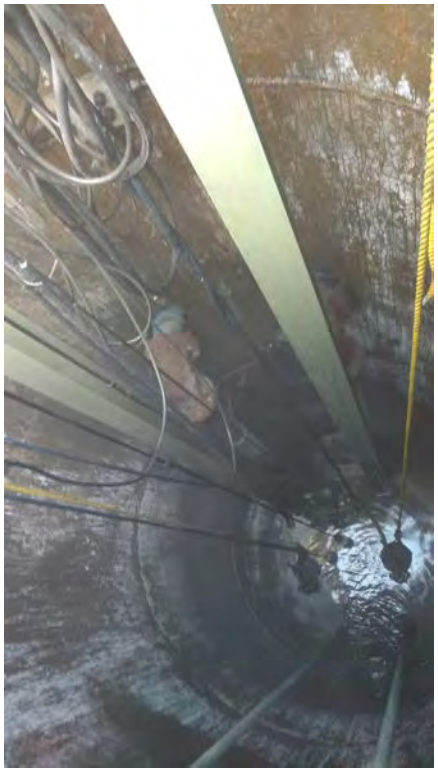

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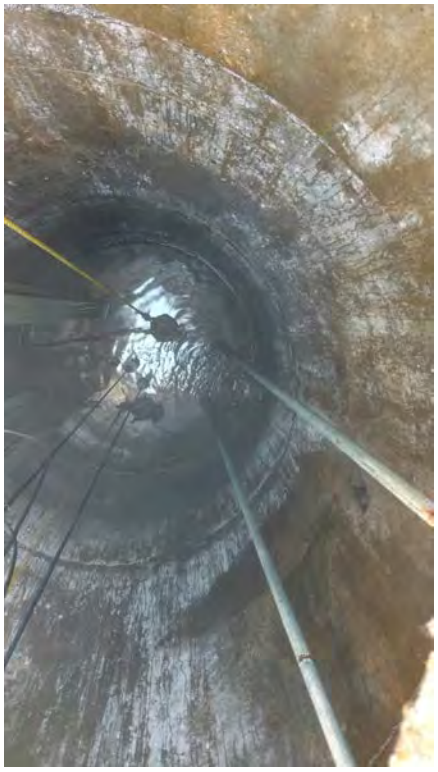

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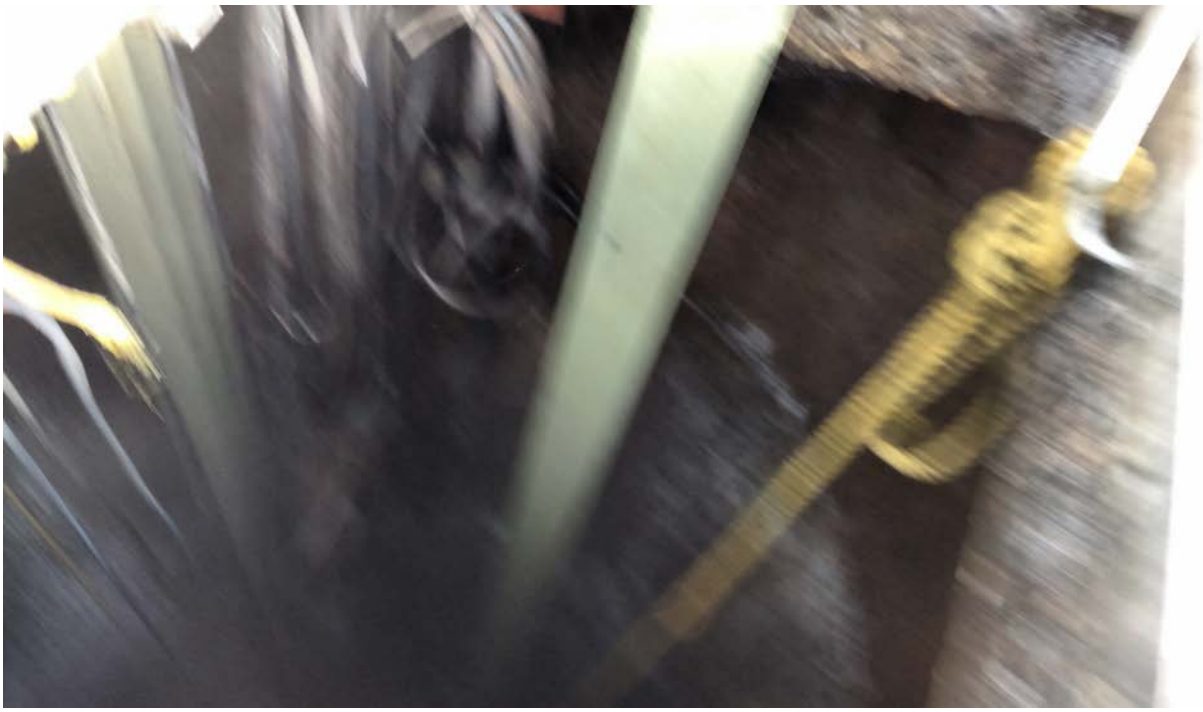

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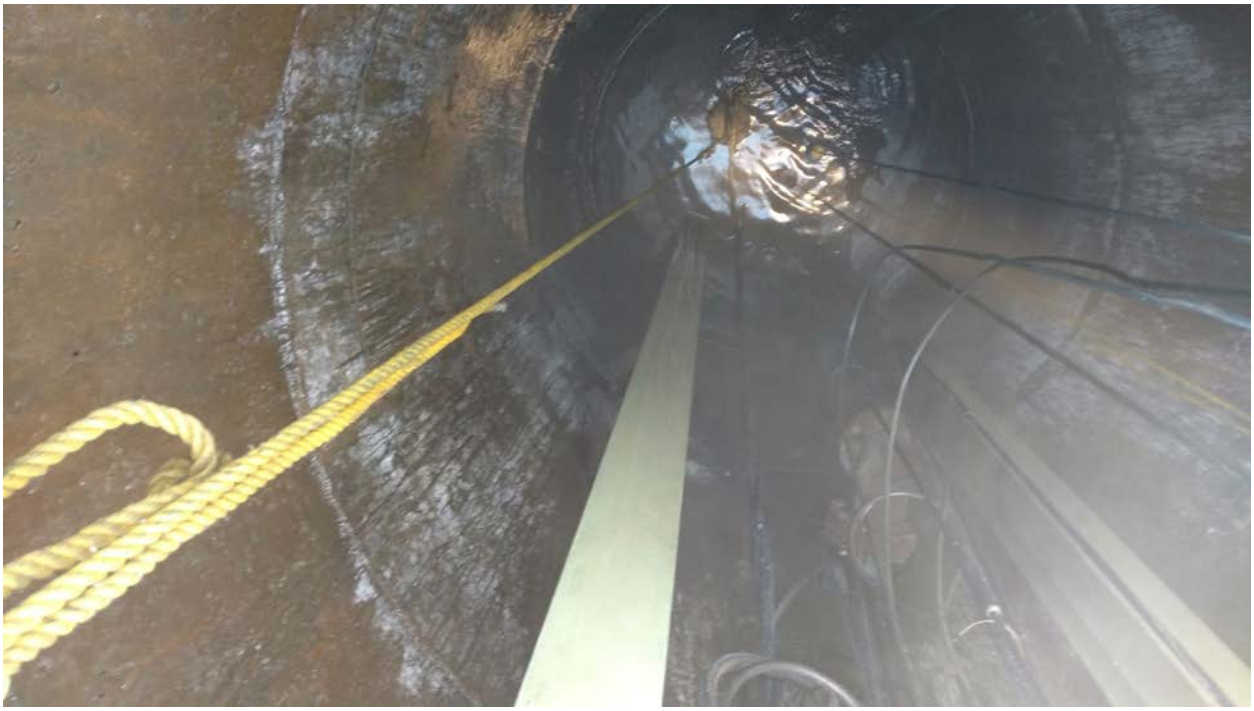

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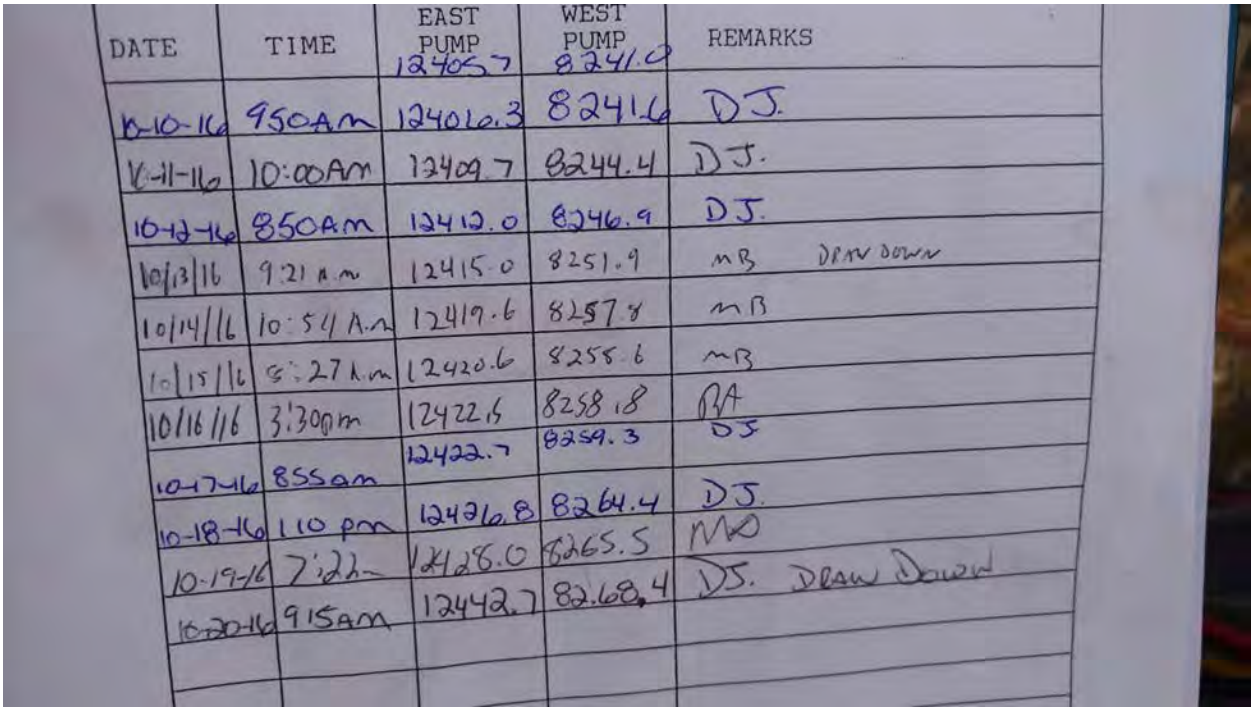
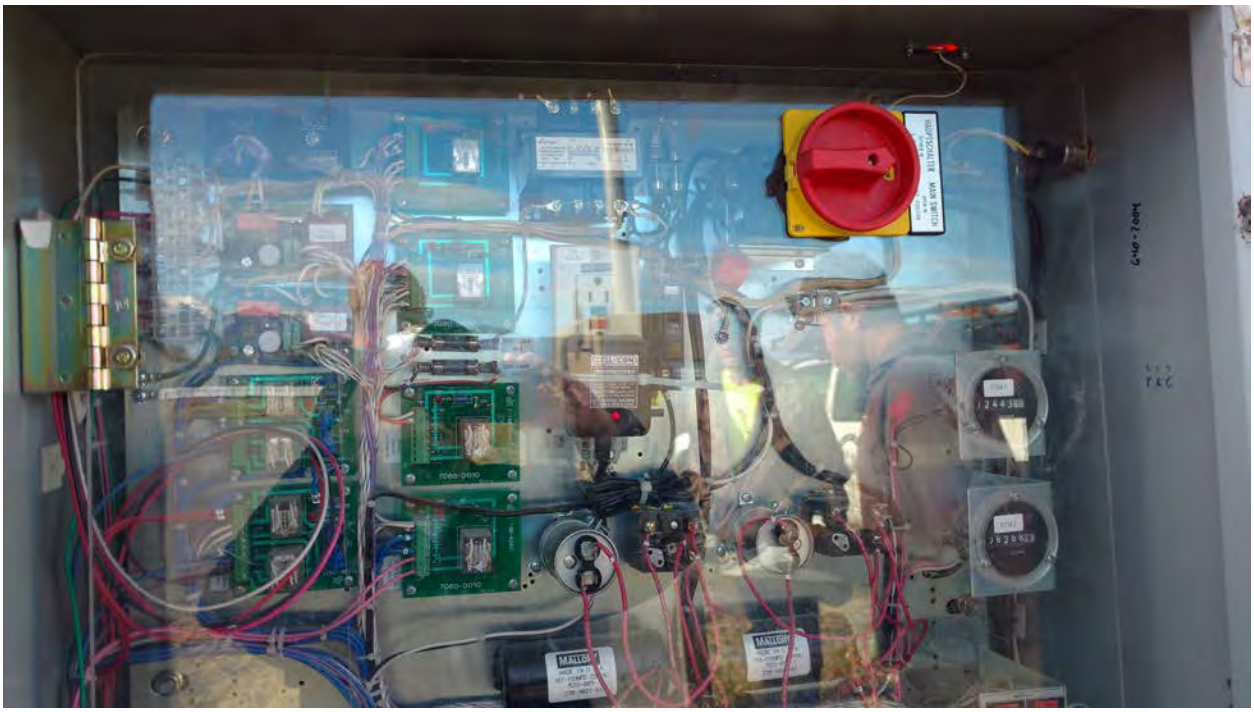


DATE	TIME	EAST PUMP	WEST PUMP	REMARKS
		12405.7	8241.0	
10-10-16	950AM	12406.3	8241.6	DJ.
10-11-16	10:00AM	12409.7	8244.4	DJ.
10-12-16	850AM	12412.0	8246.9	DJ.
10/13/16	9:21 A.m	12415.0	8251.9	MB DRAW DOWN
10/14/16	10:54 A.m	12419.6	8257.8	MB
10/15/16	5:27 A.m	12420.6	8258.6	MB
10/16/16	3:30pm	12422.6	8258.8	BA
10-17-16	855am	12422.7	8259.3	DJ
10-18-16	110 pm	12426.8	8264.4	DJ.
10-19-16	7:22	12428.0	8265.5	MO
10-20-16	915AM	12442.7	8268.4	DJ. DRAW DOWN

IMG_20161020_103951527_FARMERS.jpg



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IMG_20161020_104002269_FARMERS.jpg

IMG_20161020_104013498_FARMERS.jpg

IMG_20161020_104022277_HDR_FARMERS.jpg

Gallatin Farmers Lift Station

IMG_20161020_104033755_FARMERS.jpg

IMG_20161020_104041420_HDR_FARMERS.jpg

IMG_20161020_104046600_HDR_FARMERS.jpg

IMG_20161020_104057267_HDR_FARMERS.jpg

Gallatin Farmers Lift Station

IMG_20161020_104112724_FARMERS.jpg

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IMG_20161020_104319390_FARMERS.jpg

IMG_20161020_104456715_FARMERS.jpg

IMG_20161020_104524226_FARMERS.jpg

IMG_20161020_104535921_FARMERS.jpg

IMG_20161020_104630551_FARMERS.jpg

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SID #78 Lift Station

IMG_4212_SID78.JPG

IMG_4213_SID78.JPG

SID #78 Lift Station

IMG_4214_SID78.JPG

IMG_4215_SID78.JPG

SID #78 Lift Station

IMG_4216_SID78.JPG

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SID #78 Lift Station

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IMG_20161020_102434892_SID78.jpg

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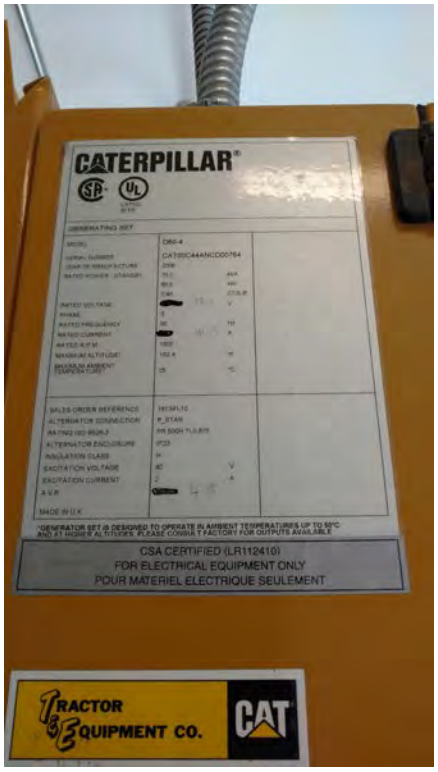

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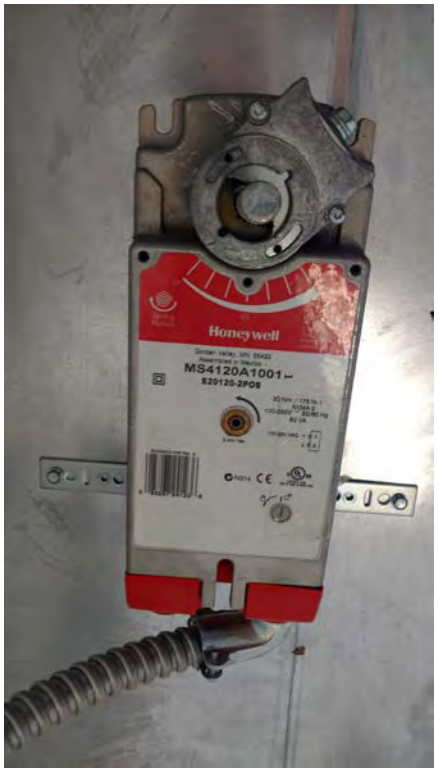

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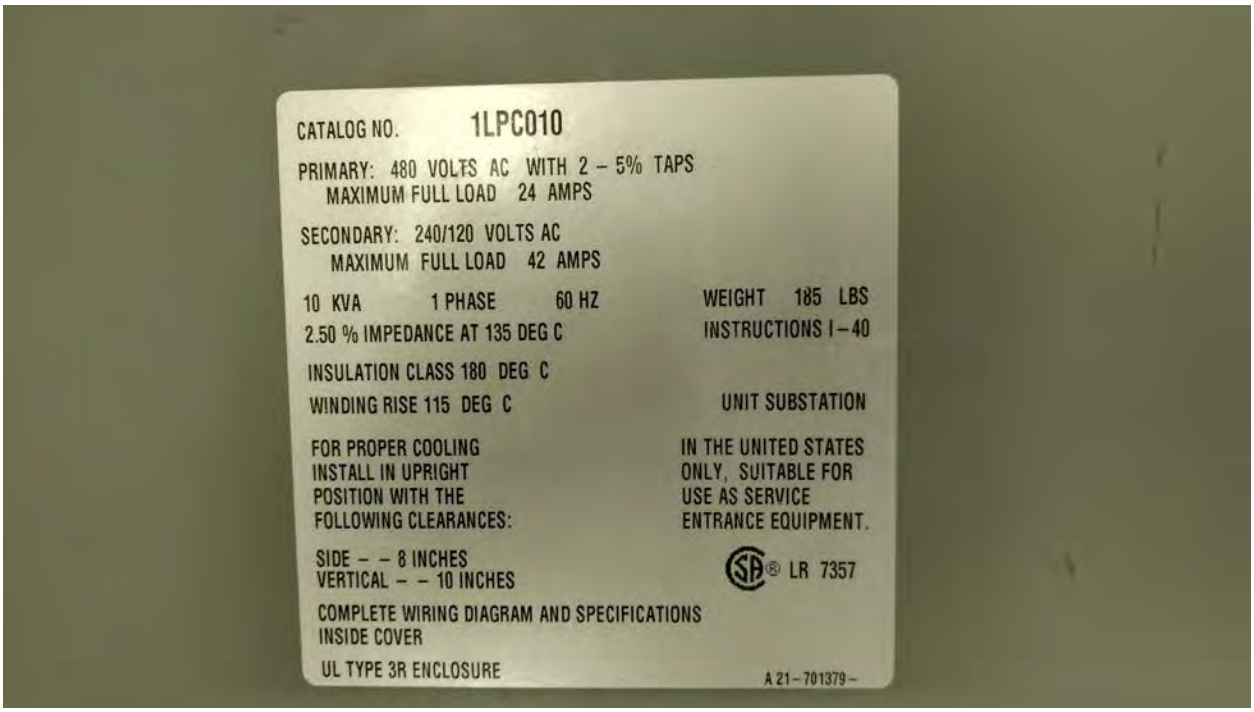

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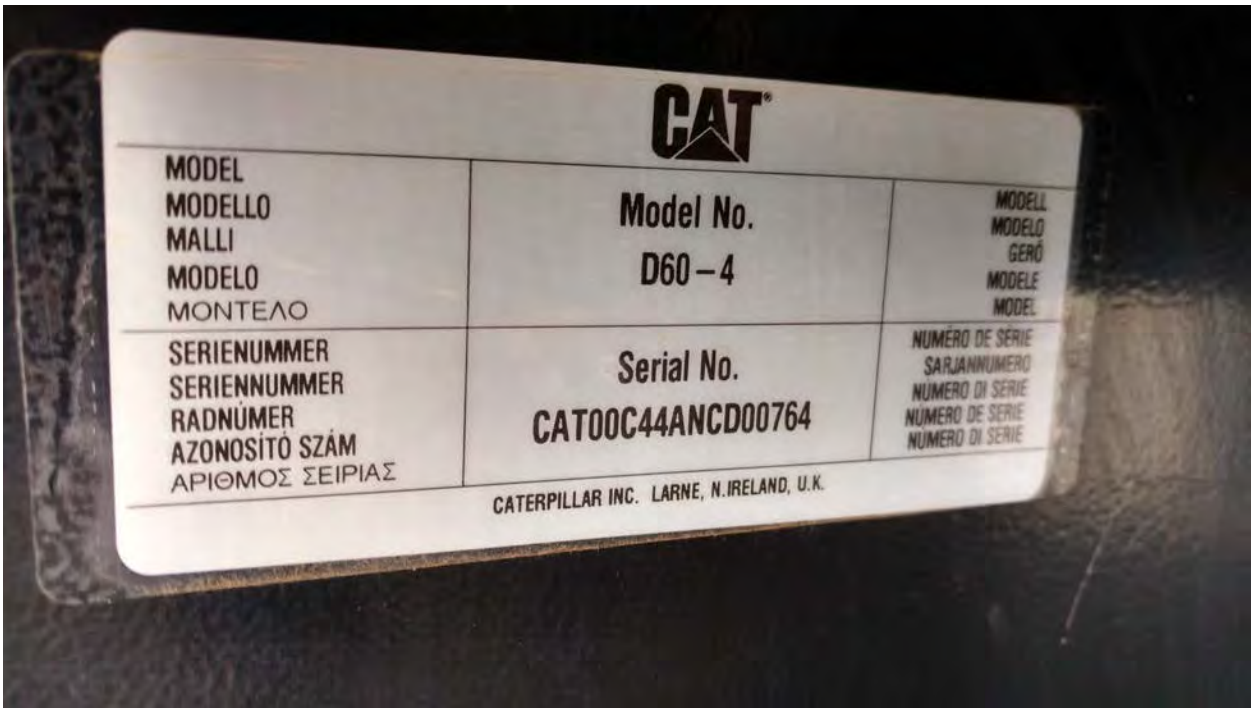
SID #78 Lift Station



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SID #78 Lift Station

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PHOT0001_SID78.JPG

SID #78 Lift Station

PHOT0002_SID78.JPG

PHOT0003_SID78.JPG

SID #78 Lift Station

PHOT0004_SID78.JPG

PHOT0005_SID78.JPG

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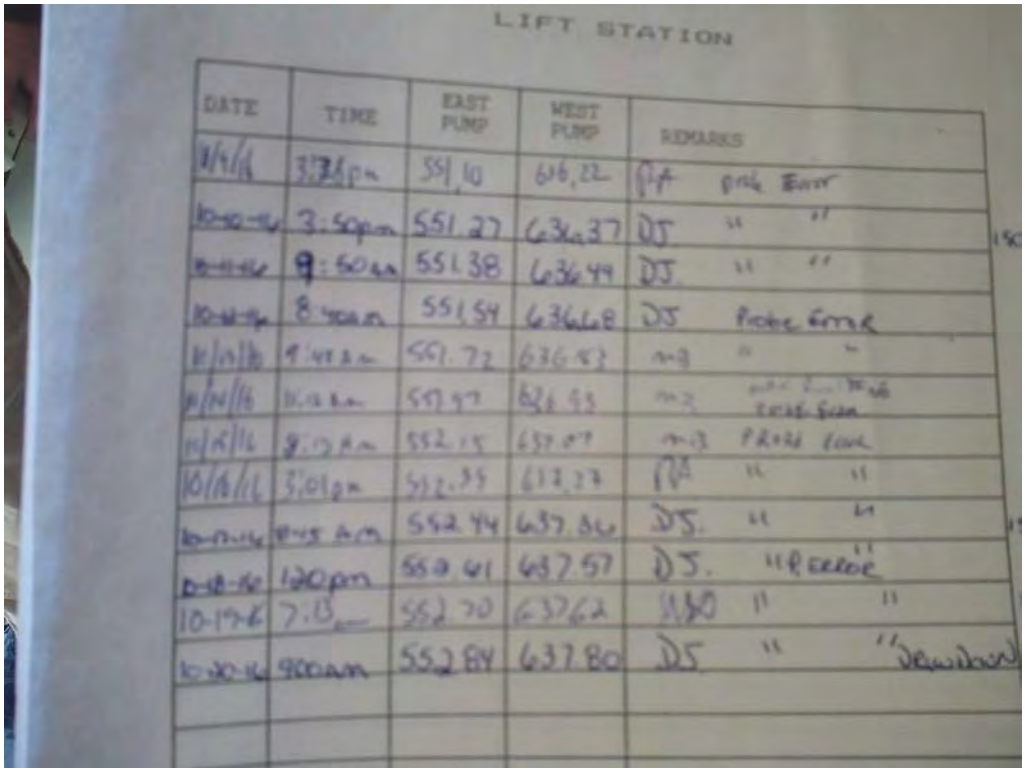
SID #78 Lift Station



LIFT STATION

DATE	TIME	EAST PUMP	WEST PUMP	REMARKS
[illegible]	[illegible]	551.10	636.22	[illegible]
[illegible]	3:50pm	551.27	636.37	DJ " "
[illegible]	9:50am	551.38	636.49	DJ " "
[illegible]	8:40am	551.54	636.68	DJ Probe Error
[illegible]	9:40am	551.72	636.83	[illegible]
[illegible]	[illegible]	551.97	636.93	[illegible]
[illegible]	[illegible]	552.15	637.07	[illegible] Probe Error
10/18/16	3:01pm	552.35	637.27	[illegible] " "
[illegible]	8:15 AM	552.44	637.36	DJ. " "
[illegible]	1:00pm	550.61	637.57	DJ. " Probe "
10-19-16	7:15 [illegible]	552.70	637.62	[illegible] " "
10-20-16	9:00AM	552.84	637.80	DJ " " Jewidson

PHOT0010_SID78.JPG

PHOT0011_SID78.JPG

PHOT0068_MEADOWLARK.JPG

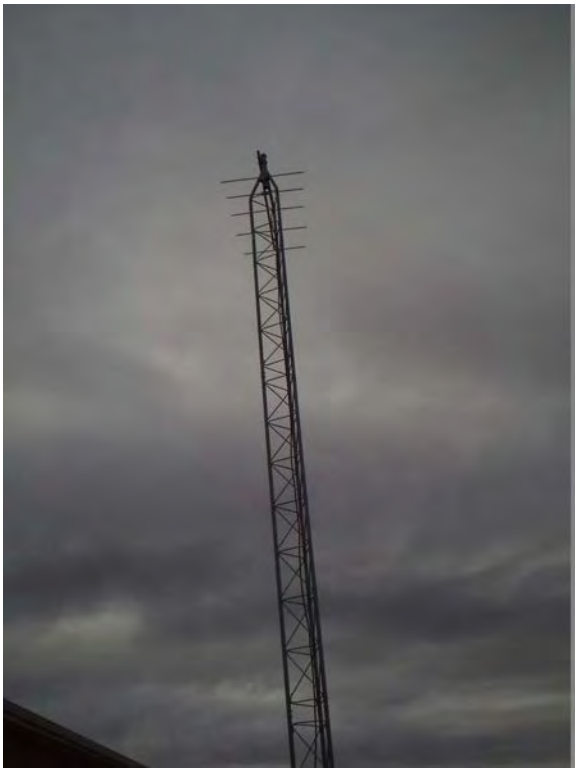
PHOT0069_MEADOWLARK.JPG

Meadowlark Lift Station

PHOT0070_MEADOWLARK.JPG

PHOT0071_MEADOWLARK.JPG

Meadowlark Lift Station



PHOT0072_MEADOWLARK.JPG

PHOT0073_MEADOWLARK.JPG

Meadowlark Lift Station

PHOT0074_MEADOWLARK.JPG

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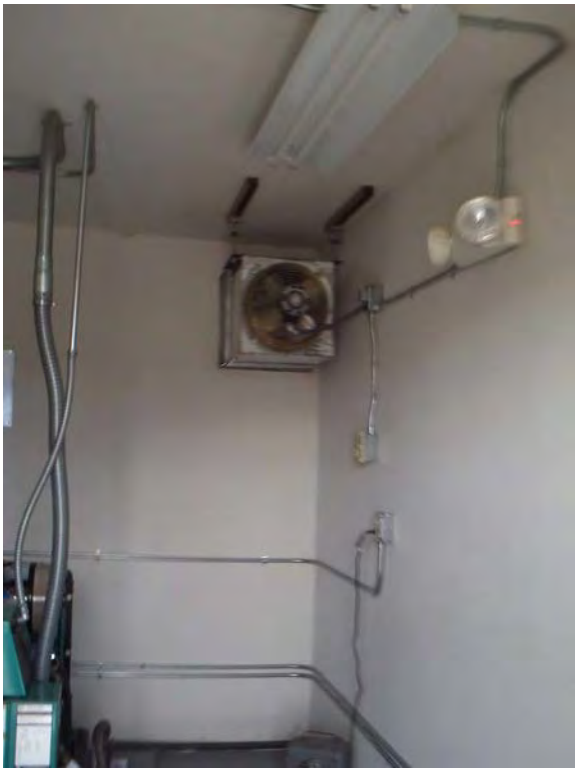
PHOT0076_MEADOWLARK.JPG

PHOT0077_MEADOWLARK.JPG

Meadowlark Lift Station



PHOT0078_MEADOWLARK.JPG

PHOT0079_MEADOWLARK.JPG

Meadowlark Lift Station

PHOT0080_MEADOWLARK.JPG

PHOT0081_MEADOWLARK.JPG

PHOT0082_MEADOWLARK.JPG

PHOT0083_MEADOWLARK.JPG

PHOT0084_MEADOWLARK.JPG

PHOT0085_MEADOWLARK.JPG

Meadowlark Lift Station

PHOT0086_MEADOWLARK.JPG

PHOT0087_MEADOWLARK.JPG

PHOT0088_MEADOWLARK.JPG

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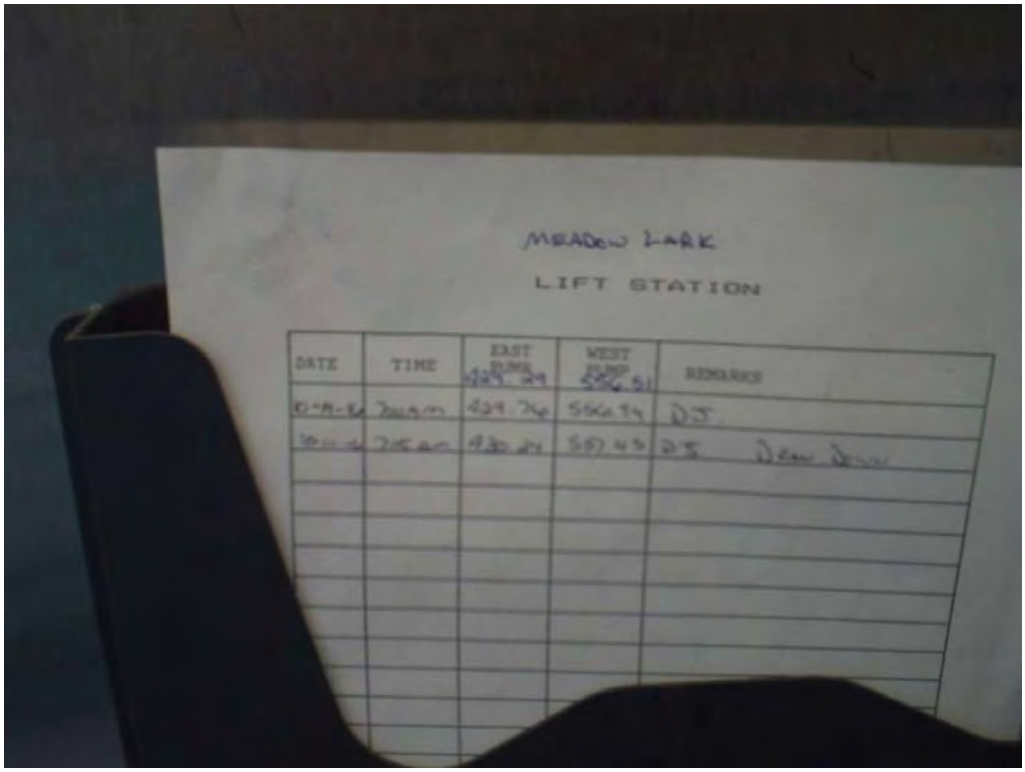
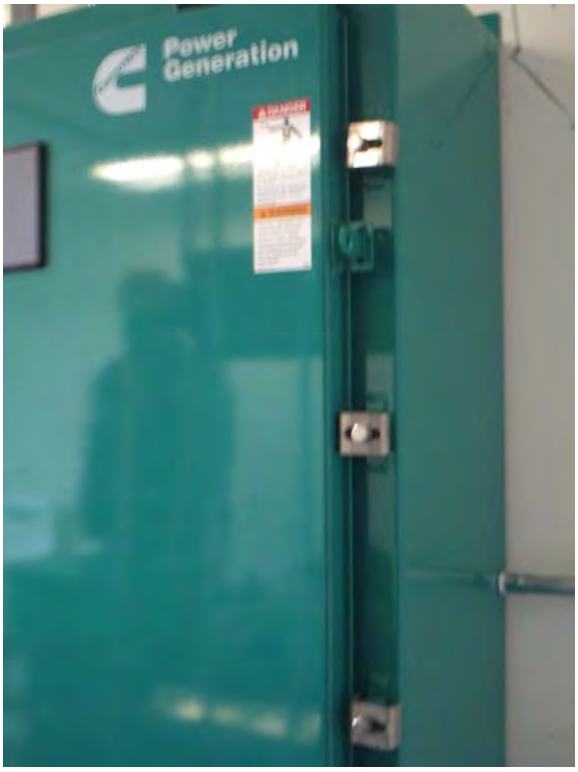


PHOT0092_MEADOWLARK.JPG

PHOT0093_MEADOWLARK.JPG

Meadowlark Lift Station

PHOT0094_MEADOWLARK.JPG



PHOT0095_MEADOWLARK.JPG

PHOT0096_MEADOWLARK.JPG

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PHOT0099_MEADOWLARK.JPG

PHOT0100_MEADOWLARK.JPG

PHOT0101_MEADOWLARK.JPG

PHOT0102_MEADOWLARK.JPG

PHOT0103_MEADOWLARK.JPG

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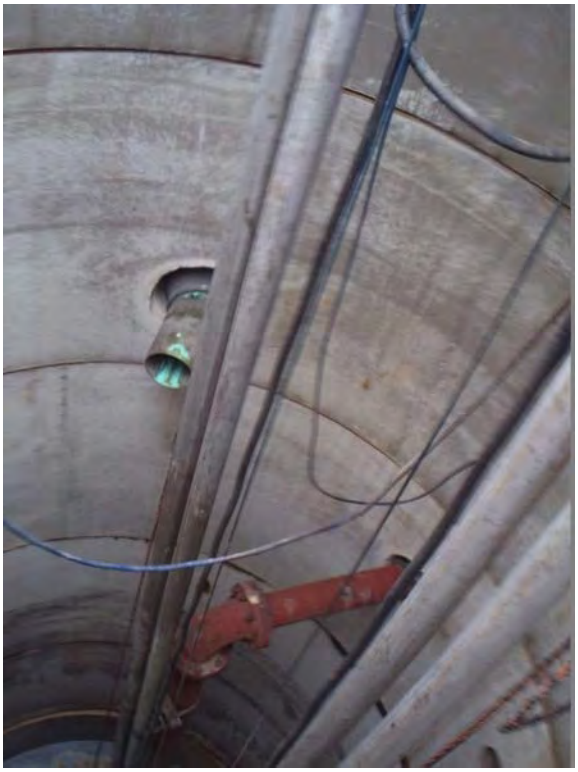
Meadowlark Lift Station



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Meadowlark Lift Station

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Meadowlark Lift Station

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Meadowlark Lift Station

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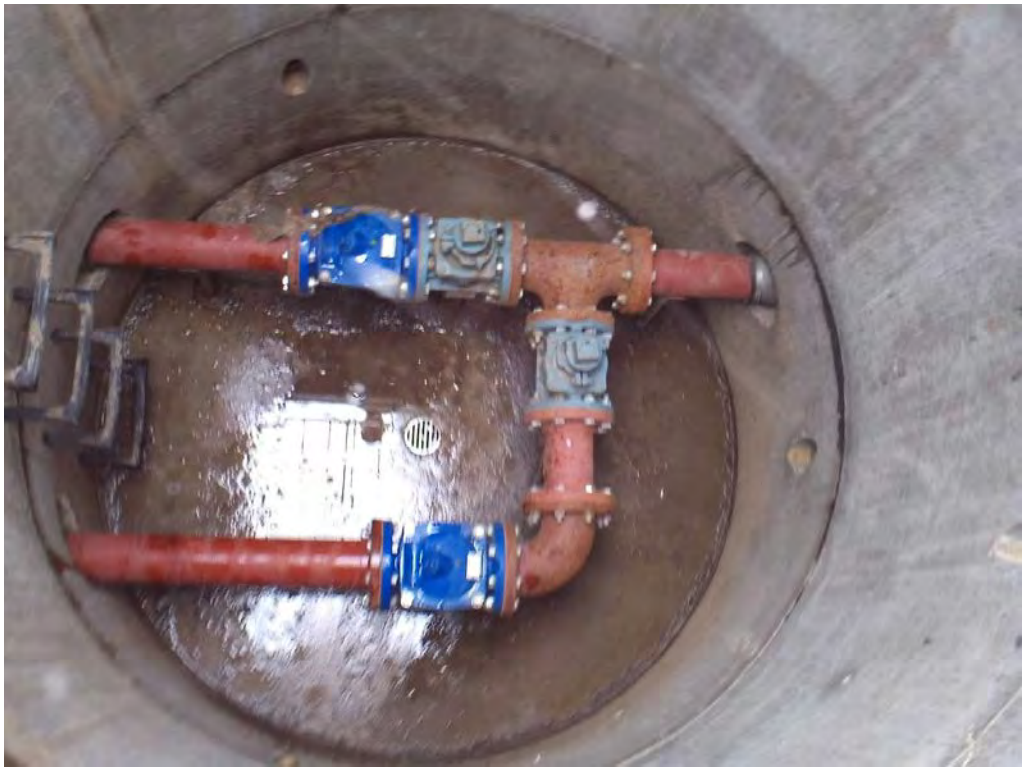

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Meadowlark Lift Station

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Ryen Glenn Lift Station

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Ryen Glenn Lift Station

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Ryen Glenn Lift Station

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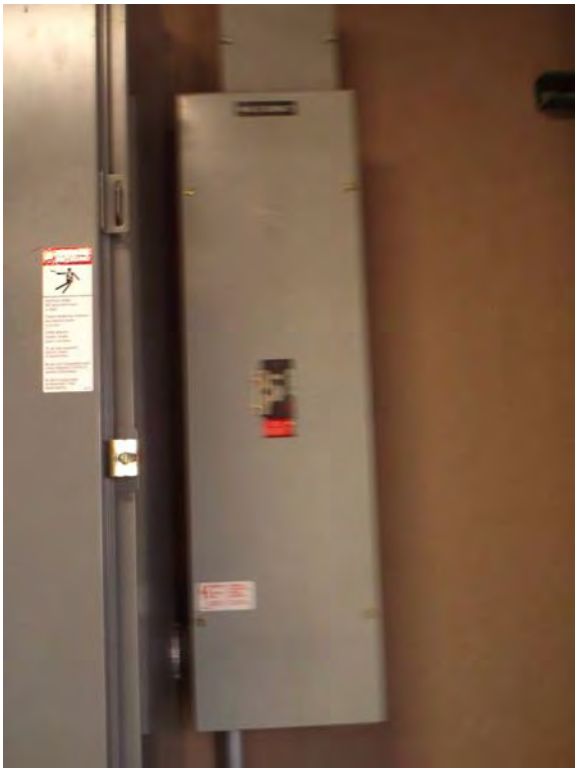
Ryen Glenn Lift Station



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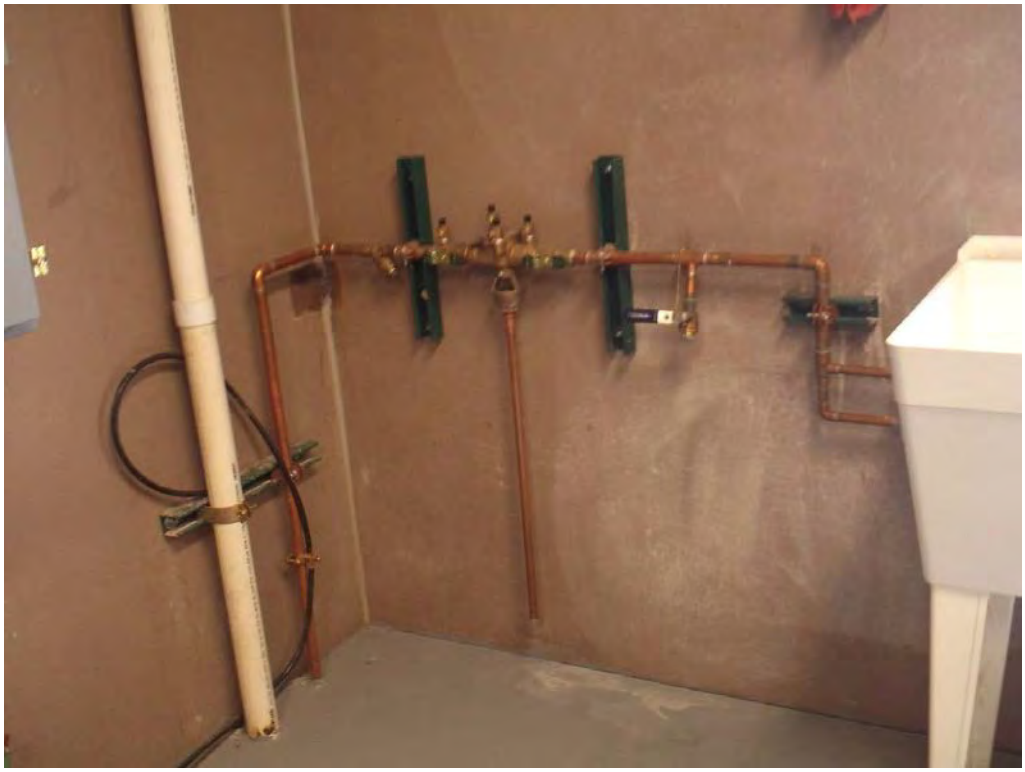

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Ryen Glenn Lift Station

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Ryen Glenn Lift Station

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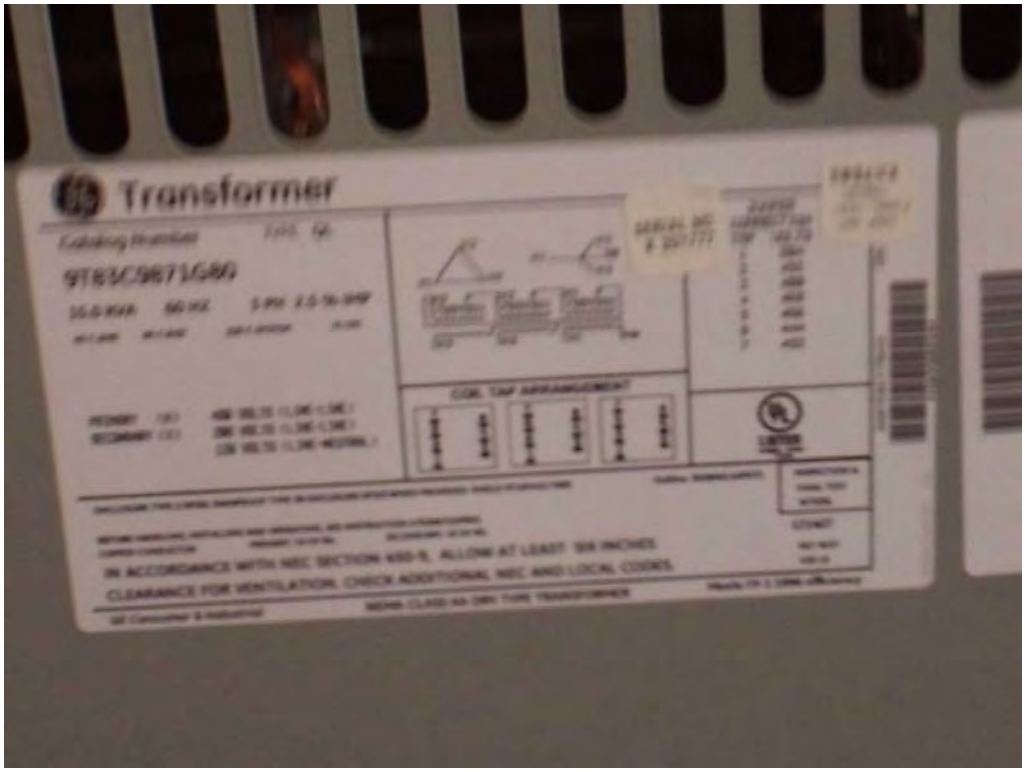

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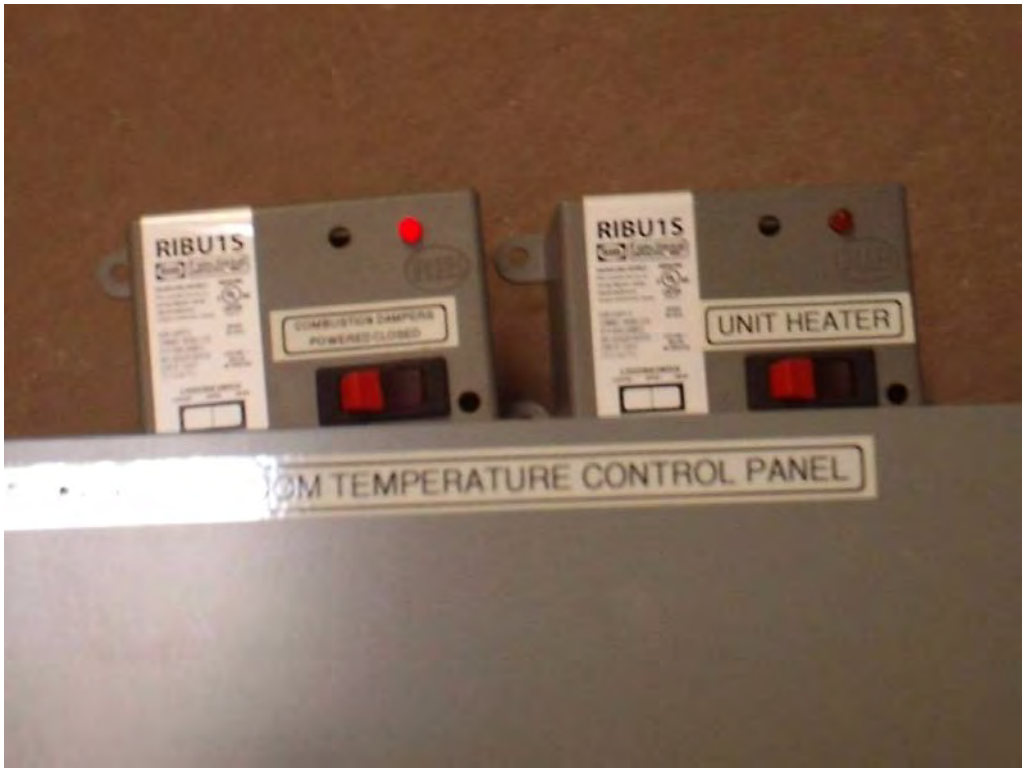

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Ryen Glenn Lift Station

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Ryen Glenn Lift Station

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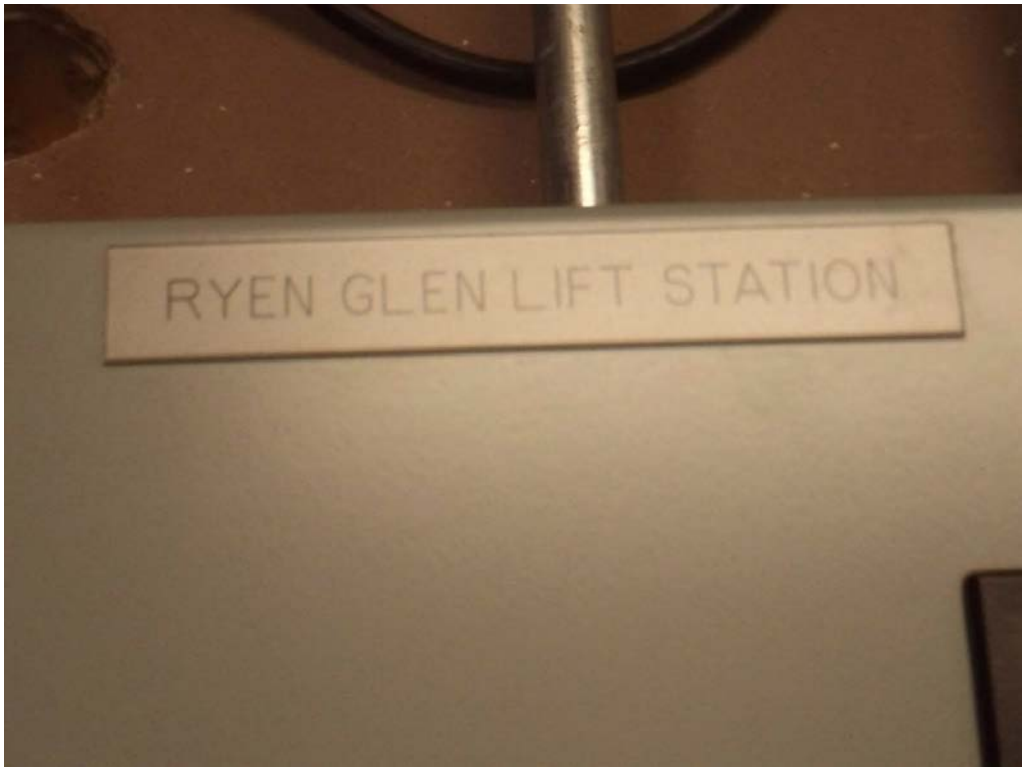

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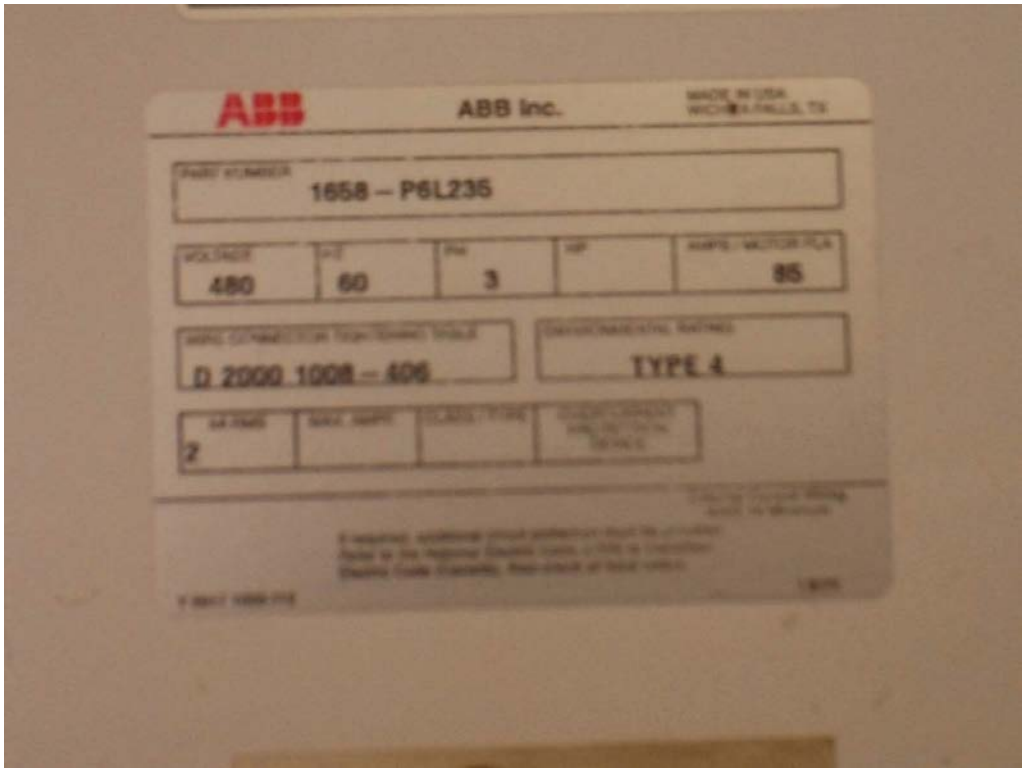

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Ryen Glenn Lift Station

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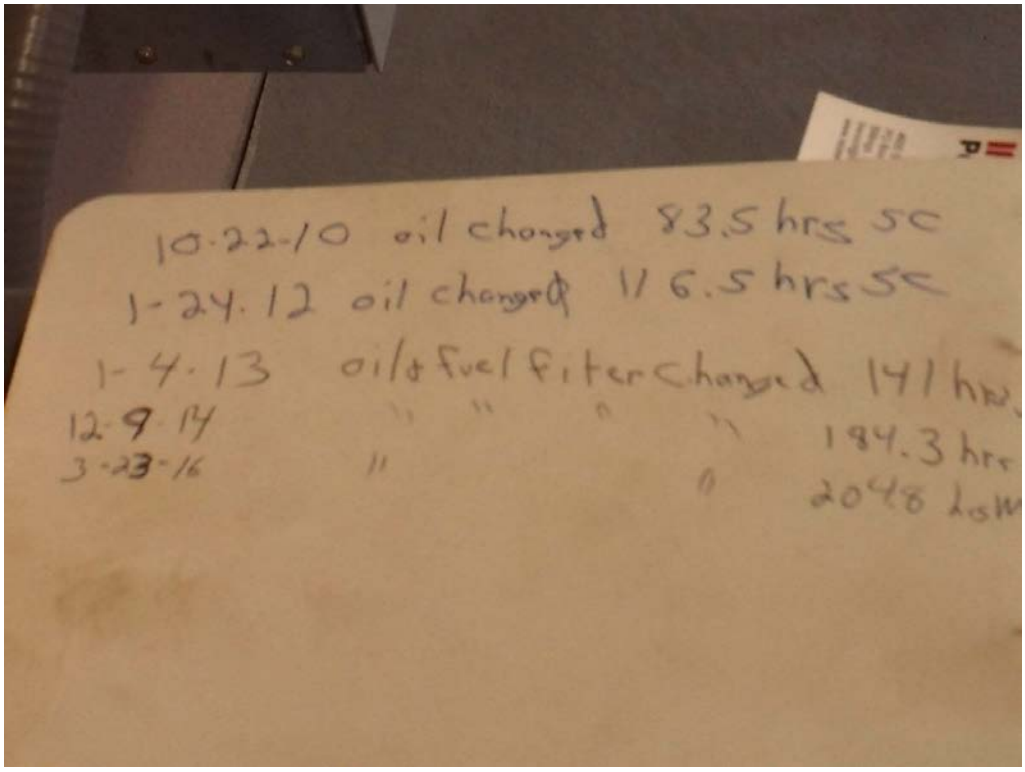

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PHOT0066_RYENGLENN.JPG

PHOT0067_RYENGLENN.JPG

Ryen Glenn Force Main

Diversion Box.JPG

Force Main MH.JPG

Inaide Trunk Main MH-2.JPG

Inside Diversion Box.JPG

Inside Force Main MH.JPG

Inside Trunk Main MH-1.JPG

Inside Wier Box MH.JPG

Trunk Main MH.JPG

Ryen Glenn Force Main

Wier Box MH .JPG

LIFT STATION DRAW DOWN TESTS

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Test by: Matt McGee, 2017-04-13, 9:30 AM
Calculated by: CEVJ
Date: 2017-04-17

BLUE = USER INPUT
RED = OUTPUT RESULT

Jackrabbit Lift Station
Draw Down Test

Wet Well Measurements

Round concrete wet well, 6 ft diameter

Area = **28.3 SF**
Depth to Fill Stop/Lead Pump Start = **20.30 ft**
Depth to Fill Start/Lead Pump Stop = **24.30 ft**
Lead Pump Wet Well Depth = 4.00 ft
Lead Pump Wet Well Volume = **113.1 CF** (846.0 gallons)

Draw Down Test Times

Event	Duration (min:sec)	Duration (min)
Fill Stop and Pump #1 Run	**2:05**	2.08
Pump #1 Stop and Wet Well Fill	**6:11**	6.18
Fill Stop and Pump #2 Run	**2:10**	2.17
Pump #2 Stop and Wet Well Fill	**6:10**	6.17

Analysis and Results

Two wet well fill cycles were observed during the draw down test. Use the average duration to calculate the average inflow to the wet well.

Average Wet Well Fill Duration = 6.2 min
Average Wet Well Inflow = **137.0 gpm**

Use the lead pump wet well volume to calculate the net wet well flow rate for each pump. The net flow rate is equal to the wet well outflow minus the inflow.

Wet Well Net Flow (w/ Pump #1) = **406.1 gpm** (Duration = 2.08 min)
Wet Well Net Flow (w/ Pump #2) = **390.5 gpm** (Duration = 2.17 min)

Calculate the length of one pump cycle for each pump and the frequency of motor starts.

Pump #1 Cycle Duration = **8.3 min**
Pump #1 Run Cycle Frequency = **7.3 pump starts per hour**

Pump #2 Cycle Duration = **8.3 min**
Pump #2 Run Cycle Frequency = **7.2 pump starts per hour**

Determine the pumping rate using the average inflow and the net flow rate.

Pump #1 Flow Rate = **543.1 gpm** (1.21 cfs)
Pump #2 Flow Rate = **527.5 gpm** (1.18 cfs)

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Test by: Matt McGee, 2016-11-16, 10 AM to 11 AM
Calculated by: CEVJ
Date: 2016-12-09

BLUE = USER INPUT
RED = OUTPUT RESULT

Cruiser Lift Station
Draw Down Test

Wet Well Measurements

Square concrete wet well, 7.5 ft by 7.5 ft inside dimensions

Area = **56.3 SF**
Depth to Fill Stop/Lead Pump Start = **19.13 ft**
Depth to Fill Start/Lead Pump Stop = **21.49 ft**
Lead Pump Wet Well Depth = 2.36 ft
Lead Pump Wet Well Volume = **132.8 CF** (993.0 gal)

Draw Down Test Times

Event	Duration (min:sec)	Duration (min)
Fill Stop and West Pump Run	**3:29**	3.48
West Pump Stop and Wet Well Fill	**11:25**	11.42
Fill Stop and East Pump Run	**4:33**	4.55
East Pump Stop and Wet Well Fill	**16:12**	16.20

Analysis and Results

Two wet well fill cycles were observed during the draw down test. Use the average duration to calculate the average inflow to the wet well.

Average Wet Well Fill Duration = 13.8 min
Average Wet Well Inflow = **71.9 gpm**

Use the lead pump wet well volume to calculate the net wet well flow rate for each pump. The net flow rate is equal to the wet well outflow minus the inflow.

Wet Well Net Flow (w/ West Pump) = **285.1 gpm** (Duration = 3.48 min)
Wet Well Net Flow (w/ East Pump) = **218.3 gpm** (Duration = 4.55 min)

Calculate the length of one pump cycle for each pump and the frequency of motor starts.

West Pump Cycle Duration = **17.3 min**
West Pump Run Cycle Frequency = **3.5 pump starts per hour**

East Pump Cycle Duration = **18.4 min**
East Pump Run Cycle Frequency = **3.3 pump starts per hour**

Determine the pumping rate using the average inflow and the net flow rate.

West Pump Flow Rate = **357.0 gpm** (0.80 cfs)
East Pump Flow Rate = **290.2 gpm** (0.65 cfs)

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Test by: Matt McGee, 2017-04-13
Calculated by: CEVJ
Date: 2017-04-17

BLUE = USER INPUT
RED = OUTPUT RESULT

Gallatin Farmers Avenue/W Northern Pacific Ave Lift Station
Draw Down Test

Wet Well Measurements

Round concrete wet well, 6 ft diameter (per as-builts)

Area = **28.3 SF**
Depth to Fill Stop/Lead Pump Start = **14.20 ft**
Depth to Fill Start/Lead Pump Stop = **15.30 ft**
Lead Pump Wet Well Depth = 1.10 ft
Lead Pump Wet Well Volume = **31.1 CF** (232.7 gallons)

Draw Down Test Times

Event	Duration (min:sec)	Duration (min)
Pump #2 Stop and Wet Well Fill	**5:50**	5.83
Fill Stop and Pump #1 Run	**2:15**	2.25
Pump #1 Stop and Wet Well Fill	**6:30**	6.50
Fill Stop and Pump #2 Run	**1:20**	1.33

Analysis and Results

Two wet well fill cycles were observed during the draw down test. Use the average duration to calculate the average inflow to the wet well.

Average Wet Well Fill Duration = 6.2 min
Average Wet Well Inflow = **37.7 gpm**

Use the lead pump wet well volume to calculate the net wet well flow rate for each pump. The net flow rate is equal to the wet well outflow minus the inflow.

Wet Well Net Flow (w/ Pump #1) = **103.4 gpm** (Duration = 2.25 min)
Wet Well Net Flow (w/ Pump #2) = **174.5 gpm** (Duration = 1.33 min)

Calculate the length of one pump cycle for each pump and the frequency of motor starts.

Pump #1 Cycle Duration = **8.4 min**
Pump #1 Run Cycle Frequency = **7.1 pump starts per hour**

Pump #2 Cycle Duration = **7.5 min**
Pump #2 Run Cycle Frequency = **8.0 pump starts per hour**

Determine the pumping rate using the average inflow and the net flow rate.

Pump #1 Flow Rate = **141.1 gpm** (0.31 cfs)
Pump #2 Flow Rate = **212.2 gpm** (0.47 cfs)

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Test by: Ryan Dake, 2017-03-15 and Matt McGee, 2017-04-13
Calculated by: CEVJ
Date: 2017-04-17

BLUE = USER INPUT
RED = OUTPUT RESULT

SID #78 (Truck Stop) Lift Station
Draw Down Test

Wet Well Measurements

Round concrete wet well, 8 ft diameter

Area = **50.3 SF**
Depth to Fill Stop/Lead Pump Start = **15.45 ft**
Depth to Fill Start/Lead Pump Stop = **18.60 ft**
Lead Pump Wet Well Depth = 3.15 ft
Lead Pump Wet Well Volume = **158.3 CF** (1184.4 gallons)

Draw Down Test Times

Event	Duration (min:sec)	Duration (min)	
Fill Stop and West Pump Run	**2:07**	2.12	
West Pump Stop and Wet Well Fill	**90:00**	90.00	(Assumed)
Fill Stop and East Pump Run	**0:30**	0.50	
East Pump Stop and Wet Well Fill	**120:00**	120.00	(Assumed)

Analysis and Results

Two wet well fill cycles were observed during the draw down test. Use the average duration to calculate the average inflow to the wet well.

Average Wet Well Fill Duration = 105.0 min
Average Wet Well Inflow = **11.3 gpm**

Use the lead pump wet well volume to calculate the net wet well flow rate for each pump. The net flow rate is equal to the wet well outflow minus the inflow.

Wet Well Net Flow (w/ Pump #1) = **559.6 gpm** (Duration = 2.12 min)
Wet Well Net Flow (w/ Pump #2) = **2368.9 gpm** (Duration = 0.50 min)

Calculate the length of one pump cycle for each pump and the frequency of motor starts.

Pump #1 Cycle Duration = **107.1 min**
Pump #1 Run Cycle Frequency = **0.6 pump starts per hour**

Pump #2 Cycle Duration = **105.5 min**
Pump #2 Run Cycle Frequency = **0.6 pump starts per hour**

Determine the pumping rate using the average inflow and the net flow rate.

Pump #1 Flow Rate = **570.9 gpm** (1.27 cfs)
Pump #2 Flow Rate = **2380.2 gpm** (5.30 cfs)

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Test by: City of Belgrade December 2017
Calculated by: CEVJ
Date: 2018-03-09

BLUE = USER INPUT
RED = OUTPUT RESULT

SID #78 (Truck Stop) Lift Station
Draw Down Retest

Wet Well Measurements

Round concrete wet well, 8 ft diameter

Area = **50.3 SF**

City operators did not provide a depth measurement for this draw down test. They indicated how full the wet well generally was when each pump started and stopped and report that volume in percent. The percent full likely originates from the SCADA panel in the generator building which reports wet well depth as a percent. It is likely that this percentage refers to the depth between two set points in the control panel: high water alarm depth and pumps off depth. Calculate the active volume as 30% of the volume between these set points. The notes from the test are attached.

High Water Alarm Elevation = **4464.98 ft** (from as-builts)
Pumps Off Elevation = **4459.98 ft** (from as-builts)
Total Wet Well Volume = 251.33 CF
30% Wet Well Volume = **75.4 CF** (564.0 gallons)

Draw Down Test Times

Event	Duration (min:sec)	Duration (min)
Fill Stop and West Pump Run	**1:58**	1.97
Fill Stop and East Pump Run	**2:02**	2.03

Analysis and Results

Wet well fill times were not provided by the City from the December 2017 test. The average wet well inflow to be used to estimate the pumping capacity will be the average inflow calculated during the event log analysis.

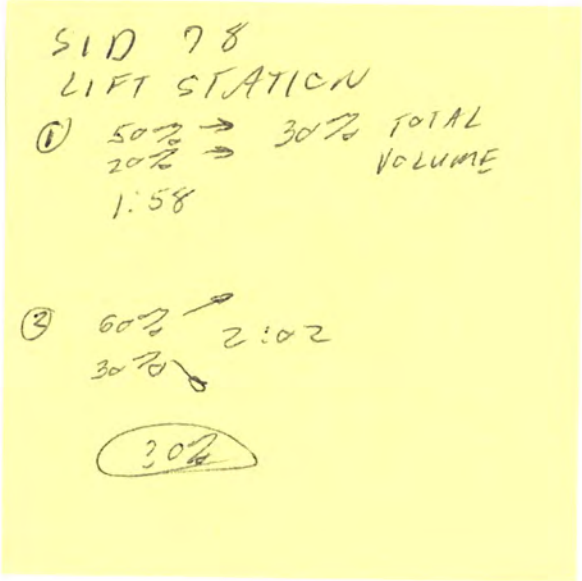
Average Wet Well Inflow = **14.0 gpm**

Use the lead pump wet well volume to calculate the net wet well flow rate for each pump. The net flow rate is equal to the wet well outflow minus the inflow.

Wet Well Net Flow (w/ Pump #1) = **286.8 gpm** (Duration = 1.97 min)
Wet Well Net Flow (w/ Pump #2) = **277.4 gpm** (Duration = 2.03 min)

Pump cycle length the frequency of motor starts cannot be calculated without wet well fill times.

Determine the pumping rate using the average inflow and the net flow rate.
Pump #1 Flow Rate = **300.8 gpm** (0.67 cfs)
Pump #2 Flow Rate = **291.4 gpm** (0.65 cfs)



Explanation of Test from TD&H:
City performed test
LS fills pretty slowly (more than 1 hr fill time)

% refer to how full the wet well was - related to % of depth between pumps off and high water alarm
Matt wasn't sure why the 2nd pump started pumping at a higher level than the 1st

1st pump - ran for 1 min 58 sec for 30% of total wet well volume
2nd pump - similar but different time

to calculate volume - look @ plans and find total wet well depth and diameter, then take 30% of the total volume

SID #78 Wet Well As-Builts:
8' Diameter
Top of wet well = 4477.60'
Bottom of wet well = 4456.98'
Lead pump on = 4462.98'
Lag pump on = 4463.98'
Pumps off = 4459.98'

LIFT STATION EVENT LOG ANALYSIS

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

6/19/2017

Jackrabbit Lift Station
Event Log Analysis Results

		Inflow			Fill Time				Pump Starts per Hour			
Year	Month	Hourly Average Flow (gpm)	Peak Hour Flow (gpm)	Peak Instantaneous Flow (gpm)	Average Wet Well Fill Time (minutes)	Minimum Wet Well Fill Time (minutes)	Maximum Wet Well Fill Time (minutes)	Instances of Fill Times Greater than 30 Minutes	Pump #1: Average Number of Pump Starts per Hour	Pump #2: Average Number of Pump Starts per Hour	Pump #1: Maximum Number of Pump Starts per Hour	Pump #2: Maximum Number of Pump Starts per Hour
2015	January	214	500	564	7.3	1.5	105.0	157	3.5	3.4	9	9
	February	216	494	529	7.1	1.6	115.8	122	3.6	3.5	9	9
	March	199	476	508	7.6	1.7	122.8	153	3.4	3.4	8	9
	April	202	503	508	7.8	1.7	126.5	174	3.4	3.3	10	8
	May	197	470	523	7.6	1.6	104.8	149	3.3	3.4	9	8
	June	220	488	513	7.2	1.6	99.1	130	3.9	3.5	13	9
	July	212	461	558	7.0	1.5	148.1	114	3.8	3.6	14	8
	August	213	474	546	6.9	1.5	95.5	111	3.5	3.7	8	8
	September	218	498	508	7.0	1.7	110.0	139	3.5	3.6	9	9
	October	206	469	508	7.1	1.7	128.2	120	3.5	3.6	9	9
	November	209	482	518	6.8	1.6	137.0	125	3.5	3.8	9	9
	December	188	476	513	7.4	1.6	122.8	139	3.4	3.5	9	9
2016	January	200	477	513	7.0	1.6	97.5	134	3.5	3.7	8	9
	February	206	489	513	7.0	1.6	117.8	140	3.5	3.7	8	9
	March	162	349	503	9.4	1.7	140.0	208	2.7	2.9	8	8
	April	161	350	360	9.3	2.3	189.4	203	2.8	3.0	9	8
	May	177	347	368	8.6	2.3	194.2	184	2.8	3.3	8	8
	June	189	350	498	7.8	1.7	202.6	146	2.8	3.6	7	7
	July	167	345	371	8.1	2.3	110.7	139	2.9	3.3	8	9
	August	178	353	382	8.2	2.2	140.1	165	2.9	3.2	8	9
	September	170	353	382	8.4	2.2	157.4	166	2.9	3.3	8	8
	October	180	346	373	8.0	2.3	110.7	173	2.7	3.6	8	8
	November	137	353	376	8.6	2.3	110.7	128	2.7	3.1	6	8
	December	108	279	355	9.5	2.4	110.5	110	2.4	2.8	5	5

Average hourly inflow = 189 gpm
Peak Hour Flow = 503 gpm
Peak Instantaneous Flow = 564 gpm

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

6/19/2017

Cruiser Lift Station
Event Log Analysis Results

		Inflow to Station			Fill Time				Pump Starts per Hour			
Year	Month	Hourly Average Flow (gpm)	Peak Hour Flow (gpm)	Peak Instantaneous Flow (gpm)	Average Wet Well Fill Time (minutes)	Minimum Wet Well Fill Time (minutes)	Maximum Wet Well Fill Time (minutes)	Instances of Fill Times Greater than 30 Minutes	Pump #1: Average Number of Pump Starts per Hour	Pump #2: Average Number of Pump Starts per Hour	Pump #1: Maximum Number of Pump Starts per Hour	Pump #2: Maximum Number of Pump Starts per Hour
2015	January	87	220	562	12.3	1.8	57.8	22	1.9	1.4	6	4
	February	88	323	584	12.2	1.7	52.3	40	1.1	1.4	2	3
	March	87	334	590	12.2	1.7	87.1	41	1.1	1.3	3	4
	April	88	262	590	12.0	1.7	59.5	36	1.3	1.4	3	4
	May	100	383	596	11.3	1.7	81.1	34	1.4	1.5	6	5
	June	111	499	596	10.8	1.7	50.7	35	1.5	1.6	6	8
	July	178	539	596	7.9	1.7	61.3	12	1.6	1.7	7	9
	August	157	584	621	9.0	1.6	47.0	21	1.4	1.9	6	7
	September	95	573	596	13.4	1.7	77.7	129	1.4	1.6	5	7
	October	116	482	596	10.7	1.7	48.7	19	1.3	1.4	7	7
	November	85	465	596	13.2	1.7	66.7	85	1.5	1.8	6	7
	December	74	214	590	14.1	1.7	65.0	41	1.4	2.0	3	5
2016	January	53	276	590	20.1	1.7	70.3	227	1.9	1.4	6	4
	February	46	119	275	23.0	3.6	83.8	252	1.1	1.4	2	3
	March	47	192	414	23.2	2.4	94.6	245	1.1	1.3	3	4
	April	54	231	414	19.8	2.4	98.4	189	1.3	1.4	3	4
	May	60	269	417	18.4	2.4	71.4	171	1.4	1.5	6	5
	June	69	303	432	17.3	2.3	214.7	151	1.5	1.6	6	8
	July	78	325	420	15.6	2.4	63.9	120	1.6	1.7	7	9
	August	92	370	445	14.0	2.2	66.4	113	1.4	1.9	6	7
	September	82	407	423	15.0	2.4	69.0	79	1.4	1.6	5	7
	October	73	411	420	15.8	2.4	49.3	100	1.3	1.4	7	7
	November	80	308	417	14.0	2.4	59.0	34	1.5	1.8	6	7
	December	77	324	417	14.0	2.4	54.0	46	1.4	2.0	3	5

Average hourly inflow = 87 gpm
Peak Hour Flow = 584 gpm
Peak Instantaneous Flow = 621 gpm

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

6/19/2017

Gallatin Farmers Lift Station
Event Log Analysis Results

		Inflow			Fill Time				Pump Starts per Hour			
Year	Month	Hourly Average Flow (gpm)	Peak Hour Flow (gpm)	Peak Instantaneous Flow (gpm)	Average Wet Well Fill Time (minutes)	Minimum Wet Well Fill Time (minutes)	Maximum Wet Well Fill Time (minutes)	Instances of Fill Times Greater than 30 Minutes	Pump #1: Average Number of Pump Starts per Hour	Pump #2: Average Number of Pump Starts per Hour	Pump #1: Maximum Number of Pump Starts per Hour	Pump #2: Maximum Number of Pump Starts per Hour
2015	January	17	68	129	64.7	1.8	1760.6	193	2.5	2.9	4	6
	February	18	65	65	63.8	3.6	1083.8	124	1.2	1.4	2	3
	March	19	76	138	68.9	1.7	1323.5	114	1.1	1.3	2	3
	April	17	65	65	78.8	3.6	1554.4	110	1.1	1.3	2	3
	May	23	122	122	63.9	1.9	1677.9	69	1.1	1.3	2	3
	June	20	121	122	74.4	1.9	1477.3	101	1.1	1.1	3	3
	July	21	66	66	89.6	3.5	1999.3	77	1.1	1.1	2	2
	August	19	66	133	78.5	1.8	1247.3	95	1.1	1.1	3	2
	September	15	44	65	75.1	3.6	1230.6	89	1.1	1.1	2	2
	October	12	44	44	126.2	5.3	1668.4	114	1.0	1.2	2	3
	November	15	122	122	110.0	1.9	1954.2	80	1.1	1.2	2	2
	December	12	44	64	132.9	3.6	1498.6	95	1.0	1.1	2	2
2016	January	14	122	122	109.9	1.9	1444.0	87	1.0	1.1	2	3
	February	23	138	138	62.8	1.7	893.4	40	1.1	1.5	5	6
	March	17	96	97	80.3	2.4	1529.0	81	1.0	1.4	3	4
	April	20	97	97	130.9	2.4	1924.1	69	1.1	1.1	2	2
	May	17	97	97	104.4	2.4	1349.9	80	1.0	1.1	2	2
	June	20	96	96	54.7	2.4	1169.0	45	1.0	1.4	2	3
	July	17	96	96	90.3	2.4	1205.6	65	1.0	1.3	2	3
	August	19	97	97	76.7	2.4	1310.2	68	1.1	1.5	2	3
	September	14	96	96	70.5	2.4	893.4	86	1.1	1.4	2	3
	October	13	48	49	122.4	4.8	1267.5	69	1.1	1.4	2	3
	November	17	98	98	88.2	2.4	881.3	68	1.1	1.6	2	4
	December	16	97	97	104.3	2.4	986.8	69	1.1	1.6	3	4

Average hourly inflow = 17 gpm
Peak Hour Flow = 138 gpm
Peak Instantaneous Flow = 138 gpm

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

6/19/2017

SID #78 Lift Station
Event Log Analysis Results

Year	Month	Inflow			Fill Time				Pump Starts per Hour			
		Hourly Average Flow (gpm)	Peak Hour Flow (gpm)	Peak Instantaneous Flow (gpm)	Average Wet Well Fill Time (minutes)	Minimum Wet Well Fill Time (minutes)	Maximum Wet Well Fill Time (minutes)	Instances of Fill Times Greater than 30 Minutes	Pump #1: Average Number of Pump Starts per Hour	Pump #2: Average Number of Pump Starts per Hour	Pump #1: Maximum Number of Pump Starts per Hour	Pump #2: Maximum Number of Pump Starts per Hour
2015	January	10	47	54	163.6	21.8	774.8	258	1.0	1.0	1	2
	February	13	355	703	144.1	1.7	489.2	257	1.0	1.0	1	2
	March	15	361	703	135.4	1.7	456.9	300	1.0	1.0	3	3
	April	15	618	618	131.1	1.9	470.1	301	1.0	1.0	2	2
	May	14	316	618	117.5	1.9	407.8	357	1.0	1.0	2	2
	June	18	365	697	94.2	1.7	353.8	413	1.0	1.0	2	2
	July	18	296	677	97.8	1.8	588.5	381	1.0	1.0	2	1
	August	20	664	697	96.1	1.7	438.8	412	1.0	1.0	2	2
	September	17	355	703	102.5	1.7	744.3	389	1.0	1.0	2	2
	October	19	358	703	105.7	1.7	334.2	370	1.0	1.0	2	2
	November	12	90	165	139.2	7.2	439.0	292	1.0	1.0	1	1
	December	17	313	618	115.1	1.9	635.3	334	1.0	1.0	2	2
2016	January	13	73	130	122.9	9.1	590.8	336	1.0	1.0	1	1
	February	16	171	332	110.2	3.6	506.9	349	1.0	1.0	2	2
	March	13	249	493	149.5	2.4	724.6	272	1.0	1.0	2	2
	April	11	256	493	172.5	2.4	869.2	240	1.0	1.0	2	1
	May	13	249	490	128.1	2.4	511.7	329	1.0	1.0	1	2
	June	14	248	493	130.3	2.4	655.9	315	1.0	1.0	2	1
	July	14	487	493	148.7	2.4	695.7	273	1.0	1.0	2	1
	August	13	328	497	145.8	2.4	748.0	285	1.0	1.0	2	2
	September	12	261	508	168.1	2.3	603.1	245	1.0	1.0	1	2
	October	11	124	245	182.2	4.8	939.9	233	1.0	1.0	2	2
	November	8	87	123	231.5	9.7	964.6	166	1.0	1.0	2	2
	December	10	249	493	192.7	2.4	782.9	211	1.0	1.0	1	1

Average hourly inflow = 14 gpm
Peak Hour Flow = 664 gpm
Peak Instantaneous Flow = 703 gpm

LIFT STATION ENERGY USAGE

City of Belgrade
NW Energy Records

Service Address	Account	Jan-13	Jan-13	Feb-13	Feb-13	Mar-13	Mar-13	Apr-13	Apr-13	May-13	May-13	Jun-13	Jun-13	Jul-13	Jul-13	Aug-13	Aug-13	Sep-13
		Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand
Lagoon Road	0900875-6	237	129440	192	104560	192	115680	172	96880	234	110720	253	140640	220	96160	232	115840	231.2
Lift Stn-408 Gallatin Farmer Rd	0796860-5		75		132		143		162		228		236		249		230	
Lift Stn-500 Jackrabbit	0209930-7	9	3357	10	3024	10	2847	10	2897	10	2812	12	3282	74		13	5766	8.18
Lift Stn-Cruiser/Jackrabbit	0695569-4	12	1535	10	1385	12	1408	8	1277	12	1036	8	1234	8	1067	17	1383	8.45
Lift Stn-6503 Jackrabbit	1736400-1	7	1396	6	980	9	944	6	846	5	762	4	1091	3	568	3	810	4.62
Lift Stn-1113 Powers (Meadowlark)	1795496-7	3	997	3	842	3	880	3	669	4	575	4	437	4	180	2	160	4.22
Lift Stn-1950 Penwell Bridge (Ryen Glenn)	1937143-4	12	726	8	634	6	752	6	630	7	565	4	363	6	349	5	312	5.73
Well-S Broadway	0184179-0	64	19093	64	16759	49	0	7	230	63	22114	62	38477	63	43140	64	43071	62.61
Well-#4	0185526-1	8	4640	86	6480	86	16480	86	17760	81	3440	81	1520	85	16560	82	48720	82.4
Wells-Yukon Lane	1216063-6	13	40	20	2240	12	4400	12	3280	60	4120	61	2880	60	6800	61	6200	60.4
Well-Aviation Lane	1214371-5	10	2080	11	1760	10	1680	33	1280	33	2200	33	2200	33	8000	34	3440	33.6
Lewis & Clark Pumphouse	0211009-6	6	3040	38	8640	39	27400	38	24240	38	10840	58	18280	59	30400	59	37440	58
308 Styles #3	0598596-5	48	35553	45	20296	46	1604	47	5877	49	29280	42	31657	42	28446	44	29388	42.5
		429	201972	493	167732	474	174218	428	156028	596	188692	622	242297	657	231919	616	292760	601.91

City of Belgrade
NW Energy Records

Service Address	Account	Sep-13	Oct-13	Oct-13	Nov-13	Nov-13	Dec-13	Dec-13	Yr-2013	Yr-2013	Jan-14	Jan-14	Feb-14	Feb-14	Mar-14	Mar-14	Apr-14	Apr-14
		kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh
Lagoon Road	0900875-6	128720	233.6	127200	186.4	110640	200	101680	2583.2	1378160	196.8	120400	211.2	97760	199.2	107680	232.8	94240
Lift Stn-408 Gallatin Farmer Rd	0796860-5	221		263		185		184	0	2308		113		191		235		299
Lift Stn-500 Jackrabbit	0209930-7	2609	8.18	2609	6.8	2099	6.26	2133	177.42	33435	6.71	2575	6.56	2106	12.57	2126	6.77	2343
Lift Stn-Cruiser/Jackrabbit	0695569-4	989	8.45	1240	8.45	1046	18.79	1082	131.14	14682	18.79	1204	5.06	1015	9.98	1267	6.22	1417
Lift Stn-6503 Jackrabbit	1736400-1	976	3.63	837	6.16	771	6.07	1216	63.48	11197	5.7	1285	8.42	1306	7.72	1108	5.57	857
Lift Stn-1113 Powers (Meadowlark)	1795496-7	201	2.58	473	2.83	844	3.47	997	39.1	7255	3.15	1150	3.3	996	3.08	948	3.23	643
Lift Stn-1950 Penwell Bridge (Ryen Glenn)	1937143-4	445	6.19	612	6.38	759	6.53	724	78.83	6871	5.83	744	6.34	780	5.94	741	7.02	673
Well-S Broadway	0184179-0	50410	63.27	39838	64	16657	63.65	7319	689.53	297108	63.39	43240	63.44	15144	62.76	30012	63	7064
Well-#4	0185526-1	39120	84.8	5680	86.4	18640	86.4	12640	935	191680	86.4	5280	84.8	6400	85.6	16160	86.4	2480
Wells-Yukon Lane	1216063-6	11720	61.6	2000	62	2920	13.2	5480	496.2	52080	63.2	5240	20	3720	12	4040	64.8	8200
Well-Aviation Lane	1214371-5	10040	33.6	1000	34.8	1240	10.4	1960	309.4	36880	32.8	2120	41.2	16200	10	1680	41.2	19840
Lewis & Clark Pumphouse	0211009-6	32840	38	13480	38.4	23560	5.2	1840	474.6	232000	40.4	21840	41.2	11080	39.2	26040	39.6	4000
308 Styles #3	0598596-5		46.4	15714	46.1	3849	48.9	17890	546.9	219554	47.2	14119	50.8	8217	46.7	2729	46.9	8984
		278291	590.3	210946	548.72	183210	468.87	155145	6524.8	2483210	570.37	219310	542.32	164915	494.75	194766	603.51	151040

City of Belgrade
NW Energy Records

Service Address	Account	May-14	May-14	Jun-14	Jun-14	Jul-14	Jul-14	Aug-14	Aug-14	Sep-14	Sep-14	Oct-14	Oct-14	Nov-14	Nov-14	Dec-14	Dec-14	Yr-2014
		Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand
Lagoon Road	0900875-6	234.4	119680	288	129840	249.6	112480	249.6	121600	224.8	137120	239.2	116400	222.4	114480	200	99920	2748
Lift Stn-408 Gallatin Farmer Rd	0796860-5		358		321		312		241		33		258		182		170	0
Lift Stn-500 Jackrabbit	0209930-7	6.6	2147	12	2740	20.46	1778	10.04	2203	18.09	2287	7.14	2326	6.15	2145	7.59	2127	120.68
Lift Stn-Cruiser/Jackrabbit	0695569-4	8.56	1479	8	1030	10.69	2252	8.47	1578	10.34	1553	6.81	1372	10.05	1887	9.06	1867	112.03
Lift Stn-6503 Jackrabbit	1736400-1	5.6	854	2.58	781	2.33	788	2.54	784	4.62	815	4.44	734	6.51	1092	9.9	1345	65.93
Lift Stn-1113 Powers (Meadowlark)	1795496-7	4	622	2.56	241	2.56	200	2.56	216	2.56	230	2.8	650	5.19	1383	3.27	1102	38.26
Lift Stn-1950 Penwell Bridge (Ryen Glenn)	1937143-4	7	611	5.66	507	6.07	388	6.07	419	6.35	688	6.08	810	6.5	919	6.25	801	75.11
Well-S Broadway	0184179-0	62.88	36572	62.86	39250	63.08	47586	63.08	41097	61.42	42958	59.7	42633	59.79	44260	62.09	38861	747.49
Well-#4	0185526-1	85.6	6080	81.6	3440	81.6	22400	82.4	43440	82.4	18640	84.8	5200	85.6	1280	86.4	12400	1013.6
Wells-Yukon Lane	1216063-6	12.4	2760	61.2	9480	59.6	10040	59.6	9880	62	16640	62	5920	63.6	3800	65.6	6640	606
Well-Aviation Lane	1214371-5	32.8	2360	0	0	33.2	10120	33.2	10560	38	6960	39.6	3280	37.2	2040	36.4	2480	375.6
Lewis & Clark Pumphouse	0211009-6	54.4	10440	58.8	16800	59.2	27360	59.2	32320	58.8	31680	38	21160	42	19560	42	20560	572.8
308 Styles #3	0598596-5	51.9	18201	52.7	27060	43.7	27605	43.7	23842	43.8	4434	4.3	294	46.1	4334	48.9	16997	526.7
		566.14	202164	635.96	231490	632.09	263309	620.46	288180	613.18	264038	554.87	201037	591.09	197362	577.46	205270	7002.2

City of Belgrade
NW Energy Records

Service Address	Account	Yr-2014	Jan-15	Jan-15	Feb-15	Feb-15	Mar-15	Mar-15	Apr-15	Apr-15	May-15	May-15	Jun-15	Jun-15	Jul-15	Jul-15	Aug-15	Aug-15
		kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh
Lagoon Road	0900875-6	1371600	208	136640	191.2	99680	192	107280	172	78720	233.6	100320	219.2	105760	225.6	117920	224.8	129040
Lift Stn-408 Gallatin Farmer Rd	0796860-5	2713		198		248		274		331		342		386		357		387
Lift Stn-500 Jackrabbit	0209930-7	26903	6.55	2374	7.97	2361	6.37	1733	6.99	2195	6.31	2101	10.8	2185	5.97	2139	7.19	2083
Lift Stn-Cruiser/Jackrabbit	0695569-4	17921	10.75	2084	8.88	1939	9.87	1373	7.02	1306	6.97	1318	6.66	1378	7.97	2100	12.46	2450
Lift Stn-6503 Jackrabbit	1736400-1	11749	9.7	1909	5.82	1135	11.31	1424	11.04	1110	7.69	951	2.58	717	7.94	880	2.6	807
Lift Stn-1113 Powers (Meadowlark)	1795496-7	8381	3.62	1393	2.53	849	2.55	881	2.64	772	2.64	740	2.1	293	2.57	211	2.57	195
Lift Stn-1950 Penwell Bridge (Ryen Glenn)	1937143-4	8081	7.03	943	6.87	735	6.3	781	6.75	734	4.55	680	5.68	422	5.56	521	4.48	474
Well-S Broadway	0184179-0	428677	62.17	35154	62.11	20978	61.36	42199	60.97	45489	58.35	41416	57.98	40331	59.59	44211	57.81	41360
Well-#4	0185526-1	143200	85.6	4240	82.4	2480	86.4	2880	81.6	2560	83.2	3280	85.6	20400	81.6	46400	81.6	40160
Wells-Yukon Lane	1216063-6	86360	63.2	4960	68.4	7720	62.8	4320	61.6	3360	61.6	3600	61.2	6320	42.8	20360	64.4	18920
Well-Aviation Lane	1214371-5	77640	36.4	2520	41.6	9840	33.2	1640	32.8	1200	33.2	1400	33.2	3200	33.6	14000	33.2	9840
Lewis & Clark Pumphouse	0211009-6	242840	42	9760	41.6	10920	42	24200	42	17120	39.2	23840	58	33720	57.6	32360	56.8	32360
308 Styles #3	0598596-5	156816	49.2	26713	46.3	16098	9.5	1468	6.3	1067	4.6	826	3.9	189	44.5	7495	47.4	2774
		2582881	584.22	228888	565.68	174983	523.66	190453	491.71	155964	541.91	180814	546.9	215301	575.3	288954	595.31	280850

Service Address	Account	Sep-15	Sep-15	Oct-15	Oct-15	Nov-15	Nov-15	Dec-15	Dec-15	Yr-2015	Yr-2015	Jan-16	Jan-16	Feb-16	Feb-16	Mar-16	Mar-16	Apr-16
		Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand
Lagoon Road	0900875-6	207.2	96160	247.2	131600	214.4	96560	254.4	118160	2589.6	1317840	208	129840	188.8	92880	192.8	96000	236
Lift Stn-408 Gallatin Farmer Rd	0796860-5		256		260		270		231	0	3540		220		466		444	
Lift Stn-500 Jackrabbit	0209930-7	7.74	2358	6.28	2101	6.37	1966	6.09	2147	84.63	25743	6.36	2304	8.03	2253	8.64	2331	6.65
Lift Stn-Cruiser/Jackrabbit	0695569-4	12.54	2772	8.9	1696	11.88	1843	11.75	1794	115.65	22053	6.71	1432	6.37	1422	9.34	1615	10.92
Lift Stn-6503 Jackrabbit	1736400-1	5.5	989	9.43	927	11.81	1253	12.18	2022	97.6	14124	11.58	2558	11.85	1772	11.83	1457	11.62
Lift Stn-1113 Powers (Meadowlark)	1795496-7	1.72	210	1.94	273	2.31	453	3.02	874	30.21	7144	3.53	1184	3.86	882	2.88	808	3.71
Lift Stn-1950 Penwell Bridge (Ryen Glenn)	1937143-4	5.2	484	5.58	686	5.72	792	6.3	846	70.02	8098	4.68	1017	8.07	853	4.87	813	5.6
Well-S Broadway	0184179-0	57.7	41067	57.39	18696	37.11	149	63.13	9939	695.67	380989	63.26	9324	62.76	12697	62.38	33503	60.19
Well-#4	0185526-1	82.4	17680	84.8	42320	84.8	22800	84.8	14800	1004.8	220000	84.8	12400	84.8	6320	80	2480	6.4
Wells-Yukon Lane	1216063-6	64.4	14200	60	4040	61.2	2360	62.4	4320	734	94480	66	6880	65.6	8360	64	4400	11.2
Well-Aviation Lane	1214371-5	33.2	7720	33.2	2000	23.2	1160	32.8	1920	399.6	56440	36.4	2400	41.6	9680	35.2	26480	11.2
Lewis & Clark Pumphouse	0211009-6	58.8	30080	56.8	25000	38.8	24800	40	14720	573.6	278880	40.8	8560	41.6	6600	41.6	15160	41.2
308 Styles #3	0598596-5	45.5	640	45.5	461	19.8	1528	50.9	14284	373.4	73543	51.2	8747	50.9	12000	48.2	8442	43.6
		581.9	214616	617.02	230060	517.4	155934	627.77	186057	6768.78	2502874	583.32	186866	574.24	156185	561.74	193933	448.29

Service Address	Account	Apr-16	May-16	May-16	Jun-16	Jun-16	Jul-16	Jul-16	Aug-16	Aug-16	Sep-16	Sep-16	Oct-16	Oct-16	Nov-16	Nov-16	Dec-16	Dec-16
		kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh	Demand	kwh
Lagoon Road	0900875-6	114000	238.4	100480	246.4	110720	225.6	108640	224.8	122560	236	176720						
Lift Stn-408 Gallatin Farmer Rd	0796860-5	482		563		530		530		526		392						
Lift Stn-500 Jackrabbit	0209930-7	2184	6.31	1996	7.59	2908	5.97	2032	19.2	3181	8.48	2244						
Lift Stn-Cruiser/Jackrabbit	0695569-4	1461	6.97	1252	8.49	1641	7.97	1995	11.97	1898	12.07	2638						
Lift Stn-6503 Jackrabbit	1736400-1	1519	7.69	874	9.74	1233	7.94	784	2.49	1046	6.07	863						
Lift Stn-1113 Powers (Meadowlark)	1795496-7	933	2.62	460	2.27	344	2.57	194	2.57	185	2.58	317						
Lift Stn-1950 Penwell Bridge (Ryen Glenn)	1937143-4	1003	6.08	893	5.98	760	5.56	480	4.48	450	6.81	1243						
Well-S Broadway	0184179-0	47109	59.87	41752	59.14	40100	59.59	43313	57.81	39292	57.31	46517						
Well-#4	0185526-1	720	81.6	800	82.4	18720	82.4	36960	83.2	49520	82.4	18240						
Wells-Yukon Lane	1216063-6	2880	60	2680	61.2	6000	42.8	19360	63.6	8360	62	13040						
Well-Aviation Lane	1214371-5	1880	10	920	32.4	760	33.6	12880	33.2	9360	36	5040						
Lewis & Clark Pumphouse	0211009-6	17480	52.8	23680	57.6	28680	57.2	31840	56.8	35920	56.4	26840						
308 Styles #3	0598596-5	1906	46.9	11423	48.1	21748	44.5	7343	47.4	2635	45.49	649						
		193557	579.24	187773	621.31	234144	575.7	266351	607.52	274933	611.61	294743	0	0	0	0	0	0

Service Address	Account	Yr-2016	Yr-2016
		Demand	kwh
Lagoon Road	0900875-6	1996.8	1051840
Lift Stn-408 Gallatin Farmer Rd	0796860-5	0	4153
Lift Stn-500 Jackrabbit	0209930-7	77.23	21433
Lift Stn-Cruiser/Jackrabbit	0695569-4	80.81	15354
Lift Stn-6503 Jackrabbit	1736400-1	80.81	12106
Lift Stn-1113 Powers (Meadowlark)	1795496-7	26.59	5307
Lift Stn-1950 Penwell Bridge (Ryen Glenn)	1937143-4	52.13	7512
Well-S Broadway	0184179-0	542.31	313607
Well-#4	0185526-1	668	146160
Wells-Yukon Lane	1216063-6	496.4	71960
Well-Aviation Lane	1214371-5	269.6	69400
Lewis & Clark Pumphouse	0211009-6	446	194760
308 Styles #3	0598596-5	426.29	74893
		5162.97	1988485

LIFT STATION OPERATOR LOGS

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Jackrabbit Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
12/9/2016	Probe error, cleaned probe
11/22/2016	Vac-con cleaning
11/19/2016	East pump running more
11/3/2016	Probe cleaning (dirty)
10/11/2016	High wet well, probe error
10/11/2016	Probe error
7/13/2016	West pump ran 15.8 hours, running stuck on, cleaned probe
6/9/2016	Probe error
5/28/2016	Probe error
5/6/2016	Probe error
4/10/2016	Probe error
3/6/2016	Probe error
1/23/2016	Prope error, cleaned
1/22/2016	Probe error, cleaned
1/21/2016	Probe error
1/20/2016	Cleaned probe 8:30pm
12/17/2015	Probe error
12/11/2015	Probe error, probe cleaned
11/21/2015	Probe error, cleaned
11/1/2015	Probe error
9/9/2015	Probe error, probe cleaned
8/16/2015	Probe error
4/6/2014	Probe error
4/1/2014	Cleaned probe error
8/6/2013	Vac clean wet well
7/31/2013	Pump defect, reset
7/19/2013	Reset Fault
5/4/2013	Probe fault, probe cleaned
3/10/2013	Changed time on panel
2/3/2013	Had to climb fence, lock not daisy chained

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Cruiser Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
12/7/2016	Cleaned probe; east pump stuck on
11/22/2016	Replaced gasket (west pump); vac-con cleaning
11/3/2016	East pump drawing ___ badly
10/18/2016	Runtime, 15 hours, need to replace gasket
10/17/2016	East pump running more
10/16/2016	East pump running more
10/15/2016	East pump running more
10/14/2016	East pump running more
10/13/2016	East pump running more
10/4/2016	Ran 17 hours, cleaned float, dirty
10/1/2016	Pump 2 was off
9/6/2016	East pump stuck on
8/11/2016	East pump running, runtime more
8/10/2016	East pump running quite a bit more
1/19/2016	Pump, still lead pump, switched to ACT
12/23/2015	East pump still getting repair
12/3/2015	East pump off repairing
11/28/2015	Pump 1 switched to lead pump
11/5/2015	Pump 1 pulled
10/6/2015	Seal failure
10/5/2015	Seal failure
10/4/2015	Seal failure
10/3/2015	Seal failure
10/2/2015	Seal failure
10/1/2015	Seal failure
9/30/2015	Seal failure
9/29/2015	Seal failure
9/28/2015	Seal failure
9/27/2015	Seal failure
9/26/2015	Seal failure
9/25/2015	Seal failure
9/24/2015	Seal failure
9/23/2015	Seal failure
9/22/2015	Seal failure
9/21/2015	Seal failure
9/19/2015	Seal failure
9/18/2015	Seal failure
9/15/2015	Seal failure
9/11/2015	Back on ACT

Cruiser Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
9/8/2015	Switch is on pump 2
9/4/2015	Pump 1 gasket is torn
8/15/2013	Temp changed off/on switch, pump
8/6/2013	VAC & JCT rodded lift

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Gallatin Farmers Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
12/22/2016	Draw down not possible
12/3/2016	Pump running
11/22/2016	Vac-con cleaning
10/23/2016	East pump still running
9/24/2016	Pump 1 running
9/11/2016	Pump 1 is off
9/10/2016	Pump 1 still running
8/7/2016	East pump ran 19 hours
7/25/2016	Helped run time
7/24/2016	Ran excessive
7/16/2016	14 hours, pump 1 East running
7/13/2016	East pump ran 17.8 hours, off when I arrived
6/13/2016	Pumps ran overtime, were off and set to auto
6/12/2016	East pump ran more than normal, water smells oily/looks oily
5/9/2016	Halfway up inflow pipe
5/8/2016	Water is just below inflow pipe, been that way all day
5/6/2016	Checking flow from Tshirt Factory
4/27/2016	Pulled pmps for inspection
4/18/2016	High wet well alarm pump broken was tripped off
2/10/2016	Lift cleaned, 3 inch of dye and a big rock
2/5/2016	East pump is running more
2/4/2016	Cleaned check valve 2
1/14/2016	Ran 8 hours, Pump 1
10/12/2015	Pump 2 reset
3/13/2015	Cleaned at Pump 1 check
8/24/2014	Lift vent broken

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
12/27/2016	Probe error
12/26/2016	Probe error
12/24/2016	Probe error
12/23/2016	Probe error
12/22/2016	Probe error
12/21/2016	Probe error
12/20/2016	Probe error
12/19/2016	Error, max run time
12/15/2016	Probe error
12/14/2016	Probe error
12/13/2016	Probe error
12/12/2016	Probe error
12/9/2016	Probe error
12/8/2016	Probe error
12/7/2016	Probe error
12/6/2016	Probe error
12/5/2016	Probe error
12/4/2016	Probe error
12/3/2016	Probe error
12/1/2016	Probe error
11/30/2016	Probe error
11/29/2016	Probe error
11/28/2016	Probe error
11/27/2016	Probe error
11/26/2016	Probe error
11/23/2016	Probe error
11/22/2016	Probe error, Vac-con lift cleaning
11/21/2016	Probe error
11/20/2016	Probe error
11/19/2016	Probe error
11/18/2016	Probe error
11/17/2016	Probe error
11/16/2016	Probe error
11/15/2016	Probe error
11/12/2016	Probe error
11/10/2016	Probe error
11/9/2016	Probe error
11/7/2016	Probe error
11/5/2016	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
11/4/2016	Probe error, max run time
11/3/2016	Probe error
11/2/2016	Probe error
10/27/2016	Probe error
10/26/2016	Probe error
10/25/2016	Probe error
10/24/2016	Probe error
10/23/2016	Probe error
10/22/2016	Probe error
10/21/2016	Probe error
10/20/2016	Probe error
10/19/2016	Probe error
10/18/2016	Probe error
10/17/2016	Probe error
10/16/2016	Probe error
10/15/2016	Probe error
10/14/2016	Probe error, max run time
10/13/2016	Probe error
10/12/2016	Probe error
10/11/2016	Probe error
10/10/2016	Probe error
10/9/2016	Probe error
10/8/2016	Probe error
10/7/2016	Probe error
10/6/2016	Probe error
10/5/2016	Probe error
10/1/2016	Probe error
9/30/2016	Probe error
9/29/2016	Probe error
9/28/2016	Probe error
9/27/2016	Probe error
9/26/2016	Probe error
9/25/2016	Probe error
9/24/2016	Probe error
9/23/2016	Probe error
9/22/2016	Probe error
9/21/2016	Probe error, Pump 2 reset, max run time
9/20/2016	Probe error
9/19/2016	Probe error
9/18/2016	Probe error
9/17/2016	Probe error
9/16/2016	Probe error
9/15/2016	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
9/14/2016	Probe error
9/13/2016	Probe error
9/12/2016	Probe error
9/11/2016	Probe error
9/10/2016	No faults
9/8/2016	Probe error
9/7/2016	Probe error
9/6/2016	Probe error, max run time, rest
9/4/2016	Probe error
9/3/2016	Probe error
9/2/2016	Probe error
9/1/2016	Probe error
8/31/2016	Probe error
8/30/2016	Probe error
8/29/2016	Probe error
8/28/2016	Probe error
8/27/2016	Probe error, max run time, rose pump 2
8/25/2016	Probe error
8/24/2016	Probe error
8/23/2016	Probe error
8/22/2016	Probe error
8/21/2016	Probe error
8/20/2016	Probe error
8/19/2016	Probe error
8/18/2016	Probe error
8/17/2016	Probe error
8/16/2016	Probe error
8/15/2016	Probe error
8/14/2016	Probe error
8/12/2016	No faults
8/11/2016	Probe error
8/10/2016	Probe error
8/9/2016	Probe error
8/8/2016	Probe error
8/7/2016	No faults
8/6/2016	No faults
8/5/2016	Max run time
8/4/2016	Probe error, Gen. running
8/4/2016	Probe error
8/3/2016	Probe error
8/3/2016	Probe error
8/2/2016	Probe error
8/1/2016	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
7/30/2016	Probe error
7/29/2016	Probe error
7/28/2016	Probe error
7/27/2016	Probe error
7/26/2016	Max run time, probe error
7/25/2016	Probe error
7/24/2016	Probe error
7/23/2016	Probe error
7/22/2016	Probe error
7/21/2016	Probe error
7/20/2016	Probe error
7/19/2016	Probe error
7/18/2016	Probe error
7/17/2016	Probe error
7/16/2016	No faults
7/15/2016	No faults
7/14/2016	Probe error
7/13/2016	Max run time, probe error
7/12/2016	Probe error
7/11/2016	Probe error
7/10/2016	Probe error
7/9/2016	Probe error
7/8/2016	Probe error
7/7/2016	Probe error
7/6/2016	Probe error
7/5/2016	Probe error
7/3/2016	Probe error, max run reset
7/1/2016	Probe error
6/30/2016	Probe error
6/29/2016	Probe error
6/28/2016	Probe error
6/27/2016	Probe error
6/26/2016	Probe error
6/23/2016	Probe error
6/22/2016	Probe error
6/21/2016	No faults
6/20/2016	Probe error
6/19/2016	Probe error
6/18/2016	Probe error
6/17/2016	Probe error, max run time
6/16/2016	Probe error
6/15/2016	Probe error
6/14/2016	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
6/13/2016	Probe error
6/12/2016	Probe error
6/11/2016	Probe error
6/10/2016	Probe error
6/9/2016	Probe error
6/8/2016	Probe error
6/7/2016	Probe error
6/6/2016	Probe error
6/5/2016	Probe error
6/4/2016	Probe error
6/3/2016	Probe error
6/2/2016	Probe error
6/1/2016	Probe error, max run time
5/31/2016	Probe error
5/29/2016	Probe error
5/28/2016	Probe error
5/27/2016	Probe error
5/26/2016	Probe error
5/25/2016	Probe error
5/24/2016	Probe error
5/23/2016	Probe error
5/22/2016	Probe error
5/21/2016	Probe error
5/20/2016	Probe error
5/19/2016	Probe error
5/18/2016	Probe error, reset breaker, max run time
5/17/2016	Probe error
5/16/2016	Probe error
5/15/2016	Probe error
5/14/2016	Probe error
5/13/2016	Probe error
5/12/2016	Probe error
5/11/2016	Probe error
5/10/2016	Probe error
5/9/2016	Probe error
5/8/2016	Probe error
5/7/2016	Probe error
5/6/2016	Probe error
5/5/2016	Probe error
5/4/2016	Probe error
5/3/2016	Probe error
5/2/2016	Probe error
5/1/2016	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
4/30/2016	Probe error
4/29/2016	Probe error
4/28/2016	Probe error
4/27/2016	Probe error
4/26/2016	Probe error, reset breaker for Pump 2
4/25/2016	Probe error, max run time
4/24/2016	Probe error, max run time
4/22/2016	Probe error, building smells bad
4/21/2016	Probe error
4/20/2016	Probe error
4/19/2016	Probe error
4/18/2016	Probe error
4/17/2016	Probe error
4/15/2016	Probe error
4/14/2016	Probe error
4/13/2016	Probe error
4/12/2016	Probe error
4/11/2016	Probe error, cleaned lift
4/10/2016	Probe error
4/9/2016	Probe error
4/8/2016	Probe error
4/7/2016	Probe error
4/6/2016	Probe error when Pump 1 kicked on
4/5/2016	Probe error
4/4/2016	Probe error
4/3/2016	Probe error
4/2/2016	Probe error
4/1/2016	Probe error
3/31/2016	Pump 2 breaker was off
3/30/2016	Probe error
3/29/2016	Probe error
3/26/2016	Probe error
3/25/2016	Probe error
3/24/2016	Probe error
3/23/2016	Probe error
3/22/2016	Probe error
3/21/2016	Probe error
3/20/2016	Probe error
3/19/2016	Probe error
3/17/2016	Probe error
3/16/2016	Probe error
3/15/2016	Probe error
3/14/2016	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
3/13/2016	Probe error
3/12/2016	Probe error
3/11/2016	Probe error
3/10/2016	Probe error
3/9/2016	Probe error, reset Pump 2
3/8/2016	Probe error, max run time
3/7/2016	Probe error
3/6/2016	Probe error
3/5/2016	Probe error
3/4/2016	Probe error
3/3/2016	Probe error
3/2/2016	Probe error
3/1/2016	Probe error
2/29/2016	Probe error
2/28/2016	Probe error, max run time
2/27/2016	Probe error
2/26/2016	Probe error
2/25/2016	Probe error
2/24/2016	Probe error
2/23/2016	Probe error
2/22/2016	Probe error
2/21/2016	Probe error
2/20/2016	Probe error
2/19/2016	Probe error
2/18/2016	Probe error
2/17/2016	Probe error
2/16/2016	Probe error
2/14/2016	Probe error
2/13/2016	Probe error
2/12/2016	Probe error
2/11/2016	Probe error
2/10/2016	Probe error
2/9/2016	Probe error
2/8/2016	Probe error
2/7/2016	Probe error
2/6/2016	Probe error, max run time, Pump 2 had to be reset
2/5/2016	Probe error
2/4/2016	Probe error
2/3/2016	Probe error
2/2/2016	Probe error
2/1/2016	Probe error
1/31/2016	Probe error
1/30/2016	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
1/29/2016	Probe error
1/28/2016	Probe error
1/27/2016	Probe error
1/26/2016	Probe error
1/25/2016	Probe error
1/24/2016	Probe error
1/23/2016	Probe error
1/22/2016	Probe error
1/21/2016	Probe error
1/20/2016	Probe error
1/19/2016	Probe error, Gen on, Ran
1/16/2016	Probe error
1/15/2016	Probe error
1/14/2016	Probe error
1/13/2016	Probe error
1/12/2016	Probe error, Filter loose, Gen fuel leak while running
1/11/2016	Probe error
1/10/2016	Probe error
1/9/2016	Probe error
1/8/2016	Probe error
1/7/2016	Probe error
1/6/2016	Probe error
1/5/2016	Probe error
1/4/2016	Probe error
1/3/2016	Probe error
1/2/2016	Probe error
12/31/2015	Probe error
12/30/2015	Probe error
12/29/2015	Probe error
12/28/2015	Probe error
12/24/2015	Probe error
12/23/2015	Probe error
12/22/2015	Probe error
12/21/2015	Probe error
12/18/2015	Probe error
12/17/2015	Probe error
12/16/2015	Probe error
12/15/2015	Probe error
12/13/2015	Probe error
12/11/2015	Probe error, max run time, Pump 2 reset
12/10/2015	Probe error
12/9/2015	Probe error
12/8/2015	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
12/7/2015	Probe error
12/6/2015	Probe error
12/5/2015	Probe error
12/4/2015	Probe error, max run time, Pump 2 reset
12/3/2015	Probe error
12/2/2015	10 unit probe error
12/1/2015	Probe error
11/30/2015	Probe error
11/29/2015	Probe error
11/28/2015	Probe error
11/24/2015	Probe error, Gen on
11/23/2015	Probe error
11/22/2015	Probe error
11/21/2015	Probe error
11/20/2015	Probe error
11/19/2015	Probe error
11/18/2015	Probe error
11/17/2015	Probe error
11/16/2015	Probe error
11/15/2015	Probe error
11/14/2015	Probe error
11/13/2015	Probe error
11/12/2015	Probe error, cleaned lift
11/10/2015	Probe error
11/9/2015	Probe error
11/8/2015	Probe error
11/7/2015	Probe error
11/6/2015	Probe error, power fault
11/5/2015	Probe error
11/4/2015	Probe error
11/3/2015	Probe error
11/2/2015	Probe error
11/1/2015	Probe error
10/31/2015	Probe error
10/30/2015	Probe error
10/29/2015	Probe error
10/28/2015	Probe error
10/27/2015	Probe error
10/26/2015	Probe error
10/25/2015	Probe error
10/23/2015	Probe error
10/22/2015	Probe error
10/21/2015	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
10/20/2015	Probe error
10/19/2015	Probe error
10/18/2015	Probe error
10/17/2015	Probe error
10/16/2015	Probe error
10/15/2015	Probe error
10/14/2015	Probe error
10/13/2015	Probe error
10/12/2015	Probe error, max run time
10/10/2015	Probe error
10/9/2015	Probe error, cleaned probe
10/8/2015	Probe error
10/7/2015	Probe error
10/6/2015	Probe error
10/5/2015	Probe error
10/4/2015	Probe error
10/3/2015	Probe error, cleaned probe
10/2/2015	Probe error
10/1/2015	Probe error
9/30/2015	Probe error
9/29/2015	Probe error, max run time
9/28/2015	Probe error
9/27/2015	Probe error
9/26/2015	Probe error
9/25/2015	Probe error
9/24/2015	Probe error, max run time
9/23/2015	Probe error
9/22/2015	Probe error
9/19/2015	Probe error, cleaned, lots of grease
9/18/2015	Probe error
9/17/2015	Probe error, cleaned
9/15/2015	Max run time
9/14/2015	Max run time
9/13/2015	Power fault
9/3/2015	Pump 2 tripped
8/19/2015	Max run time, cleaned probe
8/11/2015	Power failure
7/22/2015	Max run time, reset Pump 2
7/21/2015	Max run time, cleaned probe
7/7/2015	8:40am: 80%
7/6/2015	8:15am: Lift station still being run manual
7/6/2015	2:00am: 80%
7/5/2015	Well 1 high level/power failure

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
7/4/2015	Over temp 1 & 2, power failure, probe error
7/3/2015	Power failure, probe error
7/2/2015	Probe error
7/1/2015	Probe error
6/30/2015	Probe error
6/29/2015	Probe error
6/28/2015	Probe error
6/27/2015	Probe error
6/26/2015	Probe error
6/25/2015	Probe error
6/24/2015	Probe error
6/23/2015	Probe error, power fault
6/22/2015	Probe error
6/21/2015	Probe error
6/20/2015	Probe error
6/19/2015	Probe error
6/18/2015	10 unit probe error
6/17/2015	Probe error
6/16/2015	Probe error
6/15/2015	Probe error
6/14/2015	Probe error
6/13/2015	Probe error, cleaned
6/12/2015	Probe error, cleaned
6/11/2015	Probe error, cleaned
6/10/2015	Probe error, cleaned
6/9/2015	Probe error, cleaned greassy
6/8/2015	Probe error, probe was clean when removed
6/7/2015	Probe error, probe was clean when removed
6/6/2015	Max run time, probe error
6/4/2015	Max run time, probe error
6/3/2015	Probe error, max run time error
6/2/2015	Probe error
6/1/2015	Probe error
5/31/2015	
5/30/2015	Power failure, probe error
5/29/2015	Probe error
5/28/2015	Probe error
5/27/2015	Probe error
5/26/2015	Probe error
5/23/2015	Probe error
5/22/2015	Probe error
5/21/2015	Probe error
5/20/2015	Probe error

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
5/19/2015	Probe error
5/18/2015	Probe error
5/17/2015	Probe error
5/15/2015	Probe error
5/14/2015	Probe error
5/13/2015	Probe error
5/12/2015	Probe error
5/11/2015	Probe error, power fault
5/10/2015	Probe error, lots of grease
5/9/2015	Power failure, probe error
5/8/2015	Probe error, cleaned probe
5/7/2015	Probe error, cleaned probe
5/6/2015	Probe error
5/5/2015	Probe error
5/4/2015	Probe error
5/3/2015	Probe error
5/2/2015	Probe error
5/1/2015	Probe error
4/30/2015	Probe error
4/29/2015	Probe error
4/28/2015	Probe error
4/27/2015	Probe error
4/26/2015	Probe error
4/25/2015	Probe error, power failure
4/24/2015	Probe error, reset, probe cleaned
4/23/2015	Probe error, reset
4/22/2015	Probe error, reset
4/21/2015	Probe error, reset
4/18/2015	10 unit probe error
4/17/2015	Power failure/ 10 unit probe error
4/12/2015	Power failure
4/7/2015	Power fault
4/3/2015	Power fault
4/1/2015	Power fault
3/29/2015	5:04pm : Pump 2 over temp, Power failure Pump 1 over temp
3/28/2015	Max run time, 10 unit, probe error
3/26/2015	Power fault
3/22/2015	Probe error
3/14/2015	Probe error
2/21/2015	Probe error
2/17/2015	Probe error
2/15/2015	Power fault
2/10/2015	Switch reset on Pump 2

SID #78 (Truck Stop) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
1/18/2015	Power fault
1/17/2015	10 unit probe error
1/12/2015	Probe fault
1/10/2015	Power failure
1/8/2015	Power fault
12/26/2014	Power failure
6/30/2014	Max run time, high temp
6/28/2014	Max run time
6/27/2014	Max run time
6/13/2014	Power fault, Pump 2 over temp
5/3/2014	Max run time
4/18/2014	Power fault
12/14/2013	Power failure
8/24/2013	Cleaned probes, #2 was only running
3/10/2013	Changed time on panel
2/19/2013	Reset, max run time fault
2/16/2013	Max run time fault
1/6/2013	Reset power failure fault

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Meadowlark (Powers) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
11/17/2016	Clean probe
11/2/2016	Pump 2 working again
11/1/2016	Pump 2 still off
10/31/2016	Pump 2 still not pumping, max run time
10/30/2016	Drained and lifted pump, still not working, pump is spinning, Pump #2 off until fixed
10/28/2016	Max run time on P2
10/27/2016	Max run time on P2
10/25/2016	Max run time
8/6/2016	Pump 1 & over temp, high level
5/11/2016	Power outage, max run time, high wet well
4/25/2016	No faults showing
4/24/2016	Loss of communication
4/22/2016	Max run time, power fault
11/12/2014	Reset power fault
11/10/2014	Reset power fault
11/6/2014	Reset power fault
11/5/2014	Reset power fault
11/3/2014	Reset power fault
10/28/2014	Reset power fault
10/17/2014	Reset power fault
10/14/2014	Cleaned power fault
10/2/2014	Power fault
9/24/2014	Reset power fault
9/17/2014	Power fault
3/22/2014	Power failure
3/3/2014	Reset power fault
2/27/2014	Reset power fault
2/26/2014	Reset power fault
2/24/2014	Reset power fault
2/23/2014	Reset power fault
2/22/2014	Reset power fault
2/21/2014	Reset power fault
2/19/2014	Reset power fault
2/18/2014	Reset power fault
2/16/2014	Reset power fault
2/13/2014	Reset power fault
2/12/2014	Reset power fault
2/11/2014	Reset power fault

Meadowlark (Powers) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
2/7/2014	Reset power fault
2/6/2014	Reset power fault
2/5/2014	Reset power fault
2/4/2014	Reset power fault
2/3/2014	Reset power fault
2/2/2014	Power fault
2/1/2014	Reset power fault
1/31/2014	Reset power fault
1/30/2014	Reset power fault
1/29/2014	Reset power fault
1/28/2014	Reset power fault
1/27/2014	Reset power fault
1/26/2014	Reset power fault
1/24/2014	Reset power fault
1/22/2014	Reset power fault
1/21/2014	Reset power fault
1/19/2014	Reset power fault
1/14/2014	Reset power fault
1/13/2014	Reset power fault
1/12/2014	Reset power fault
1/11/2014	Reset power fault
1/10/2014	Reset power fault
1/9/2014	Power fault
1/8/2014	Power fault
1/7/2014	Power fault
1/6/2014	Power fault
1/5/2014	Power fault
1/4/2014	Power fault
1/3/2014	Power fault
1/2/2014	Power fault
12/29/2013	Power fault
12/26/2013	Power fault
12/24/2013	Power fault
12/23/2013	Power fault
12/22/2013	Power fault
12/21/2013	Power fault
12/20/2013	Power fault
12/18/2013	Power fault
12/17/2013	Power fault
12/16/2013	Power fault
12/14/2013	Power fault
12/12/2013	Power fault
12/11/2013	Power fault

Meadowlark (Powers) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
12/10/2013	Power fault
12/5/2013	Power fault
6/23/2013	No power fault
6/22/2013	Power fault
4/18/2013	Reset power, failure fault
4/11/2013	Reset power, failure fault
4/9/2013	Reset power, failure fault
3/26/2013	Reset power, failure fault
3/24/2013	Reset power, failure fault
3/23/2013	Reset power, failure fault
3/22/2013	Reset power, failure fault
3/21/2013	Reset power, failure fault
3/16/2013	No faults
3/14/2013	Reset power, failure fault
3/12/2013	Reset power, failure fault
3/10/2013	Changed time on panel
3/9/2013	No faults
3/8/2013	Reset power, failure fault
3/7/2013	Reset power, failure fault
3/6/2013	Reset power, failure fault
3/5/2013	Reset power, failure fault
3/4/2013	Reset power, failure fault
3/3/2013	No faults
2/28/2013	Reset power, failure fault
2/27/2013	Reset power, failure fault
2/26/2013	Reset power, failure fault
2/25/2013	Reset power, failure fault
2/24/2013	Reset power, failure fault
2/23/2013	Reset power, failure fault
2/22/2013	Reset power, failure fault
2/21/2013	Reset power, failure fault
2/20/2013	Reset power, failure fault
2/19/2013	Reset power, failure fault
2/16/2013	No power fault
2/15/2013	Reset power, failure fault
2/14/2013	Reset power, failure fault
2/13/2013	Reset power, failure fault
2/12/2013	Reset power, failure fault
2/11/2013	Reset power, failure fault
2/10/2013	Reset power, failure fault
2/9/2013	No power fault
2/8/2013	Reset power, failure fault
2/7/2013	Reset power, failure fault

Meadowlark (Powers) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
2/6/2013	Reset power, failure fault
2/5/2013	Reset power, failure fault
2/4/2013	Reset power, failure fault
2/3/2013	Reset power, failure fault
2/2/2013	Reset power, failure fault
2/1/2013	Reset power, failure fault
1/31/2013	Reset power, failure fault
1/30/2013	Reset power, failure fault
1/29/2013	Reset power, failure fault
1/28/2013	Reset power, failure fault
1/26/2013	Reset power fault
1/25/2013	No power fault
1/24/2013	Reset power, failure fault
1/23/2013	Reset power, failure fault
1/22/2013	Reset power, failure fault
1/20/2013	Reset power, failure fault
1/19/2013	Reset power, failure fault
1/18/2013	Reset power, failure fault
1/17/2013	Reset power, failure fault
1/16/2013	Reset power, failure fault
1/15/2013	Reset power, failure fault
1/14/2013	Reset power, failure fault
1/13/2013	Reset power, failure fault
1/10/2013	Reset power, failure fault
1/9/2013	Reset power, failure fault
1/8/2013	Reset power, failure fault
1/7/2013	Reset power, failure fault
1/6/2013	Reset power, failure fault
1/5/2013	Reset power, failure fault
1/4/2013	Reset power, failure fault
1/3/2013	Reset power, failure fault
1/2/2013	Reset power, failure fault
12/31/2012	Reset power, failure fault
12/29/2012	Reset power, failure fault
12/28/2012	Reset power, failure fault
12/27/2012	Reset power, failure fault
12/26/2012	Reset power, failure fault
12/24/2012	Reset power, failure fault
12/23/2012	Reset power, failure fault
12/22/2012	Reset power, failure fault
12/21/2012	Reset power, failure fault
12/20/2012	Reset power, failure fault
12/19/2012	Reset power, failure fault

Meadowlark (Powers) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
12/18/2012	Reset power, failure fault
12/17/2012	Reset power, failure fault
12/16/2012	Reset power, failure fault
12/15/2012	Reset power, failure fault
12/14/2012	Reset power, failure fault
12/13/2012	Reset power, failure fault
12/12/2012	Reset power, failure fault
12/11/2012	Reset power, failure fault
12/10/2012	Reset power, failure fault
12/9/2012	Reset power, failure fault

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

Ryen Glenn (Penwell) Lift Station
Maintenance and Error Summary

Information taken from lift station operator logs.

Date	Comment
11/17/2016	Clean probe
10/7/2016	Gen running
6/13/2016	Reset volt phase rotation error
6/8/2016	Probe error, gen ran
5/9/2016	Vent pipe on gen leaking from roof
8/15/2015	No water in building
4/19/2014	Volts phasr imbalance under voltage
1/12/2014	Voltage fault
11/18/2013	Could not get multismart to start up
8/16/2013	Gen running
7/13/2013	Under voltage fault
3/10/2013	Changed time on panel
1/24/2013	Panel is working again
1/20/2013	Wet well was 2.5 ft higher than inflow pipe, manually pumped wet well down
1/19/2013	Power supply is dead
1/17/2013	Multismart panel has no power
1/16/2013	Multismart panel not working, opened panel box, operated by hand jiggled
1/6/2013	Control panel not latched closed, T-handle behind panel main circuit +purple+2 circuit not on switches

FORCE MAIN CALCULATIONS

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

BLUE = USER INPUT
RED = OUTPUT RESULT

Calculated by: CEVJ
Date: 2017-04-26

Jackrabbit Lift Station
Force Main Velocity

Force Main Dimensions

Material: **Unknown**
Inside Diameter = **6.00 in** (0.500 ft)
Inside Area = **0.196 SF**

Lift Station Pumping Rates

Pump #1 = **543 gpm** (1.21 cfs)
Pump #2 = **527 gpm** (1.17 cfs)

Analysis and Results

Calculate the force main velocity for each pumping rate:

East Pump Velocity = **6.2 ft/sec**
West Pump Velocity = **6.0 ft/sec**

Find the minimum flow rate needed to achieve 2 ft/sec (DEQ's minimum):

Minimum Velocity = **2.0 ft/sec**
Flow Rate Required = **0.39 cfs** **(176 gpm)**

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

BLUE = USER INPUT
RED = OUTPUT RESULT

Calculated by: CEVJ
Date: 2017-01-18

Cruiser Lift Station
Force Main Velocity

Force Main Dimensions

Material: **10-inch DR18 C900 PVC**
Inside Diameter = **9.79 in** (0.816 ft)
Inside Area = **0.523 SF**

Lift Station Pumping Rates

East Pump = **290 gpm** (0.65 cfs)
West Pump = **357 gpm** (0.80 cfs)

Analysis and Results

Calculate the force main velocity for each pumping rate:
East Pump Velocity = **1.2 ft/sec**
West Pump Velocity = **1.5 ft/sec**

Find the minimum flow rate needed to achieve 2 ft/sec (DEQ's minimum):
Minimum Velocity = **2.0 ft/sec**
Flow Rate Required = **1.05 cfs** **(469 gpm)**

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

BLUE = USER INPUT
RED = OUTPUT RESULT

Calculated by: CEVJ
Date: 2017-05-11

Farmers Lift Station
Force Main Velocity

Force Main Dimensions

Material: **PVC**
Inside Diameter = **4.00 in** (0.333 ft)
Inside Area = **0.087 SF**

Lift Station Pumping Rates

Pump #1 = **141 gpm** (0.31 cfs)
Pump #2 = **212 gpm** (0.47 cfs)

Analysis and Results

Calculate the force main velocity for each pumping rate:
East Pump Velocity = **3.6 ft/sec**
West Pump Velocity = **5.4 ft/sec**

Find the minimum flow rate needed to achieve 2 ft/sec (DEQ's minimum):
Minimum Velocity = **2.0 ft/sec**
Flow Rate Required = **0.17 cfs** **(78 gpm)**

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

BLUE = USER INPUT
RED = OUTPUT RESULT

Calculated by: CEVJ
Date: 2017-05-18

SID #78 Lift Station
Force Main Velocity

Force Main Dimensions

Material: **PVC**
Inside Diameter = **6.00 in** (0.500 ft)
Inside Area = **0.196 SF**

Lift Station Pumping Rates

Pump #1 = **300 gpm** (0.67 cfs)
Pump #2 = **300 gpm** (0.67 cfs)

Analysis and Results

Calculate the force main velocity for each pumping rate:
East Pump Velocity = **3.4 ft/sec**
West Pump Velocity = **3.4 ft/sec**

Find the minimum flow rate needed to achieve 2 ft/sec (DEQ's minimum):
Minimum Velocity = **2.0 ft/sec**
Flow Rate Required = **0.39 cfs** **(176 gpm)**

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

BLUE = USER INPUT
RED = OUTPUT RESULT

Calculated by: CEVJ
Date: 2017-05-18

Farmers Lift Station
Force Main Velocity

Force Main Dimensions

Material: **PVC**
Inside Diameter = **4.00 in** (0.333 ft)
Inside Area = **0.087 SF**

Lift Station Pumping Rates

Pump #1 = **283 gpm** (0.63 cfs)
Pump #2 = **283 gpm** (0.63 cfs)

Analysis and Results

Calculate the force main velocity for each pumping rate:
East Pump Velocity = **7.2 ft/sec**
West Pump Velocity = **7.2 ft/sec**

Find the minimum flow rate needed to achieve 2 ft/sec (DEQ's minimum):
Minimum Velocity = **2.0 ft/sec**
Flow Rate Required = **0.17 cfs** **(78 gpm)**

BELGRADE WASTEWATER MASTER PLAN
BELGRADE, MONTANA
TD&H Job No. B16-048

BLUE = USER INPUT
RED = OUTPUT RESULT

Calculated by: CEVJ
Date: 2017-05-18

Ryen Glenn Lift Station
Force Main Velocity

Force Main Dimensions

Material: **PVC**
Inside Diameter = **8.00 in** (0.667 ft)
Inside Area = **0.349 SF**

Lift Station Pumping Rates

Pump #1 = **520 gpm** (1.16 cfs)
Pump #2 = **520 gpm** (1.16 cfs)

Analysis and Results

Calculate the force main velocity for each pumping rate:
East Pump Velocity = **3.3 ft/sec**
West Pump Velocity = **3.3 ft/sec**

Find the minimum flow rate needed to achieve 2 ft/sec (DEQ's minimum):
Minimum Velocity = **2.0 ft/sec**
Flow Rate Required = **0.70 cfs** **(313 gpm)**

JM Eagle *Building essentials for a better tomorrow™*

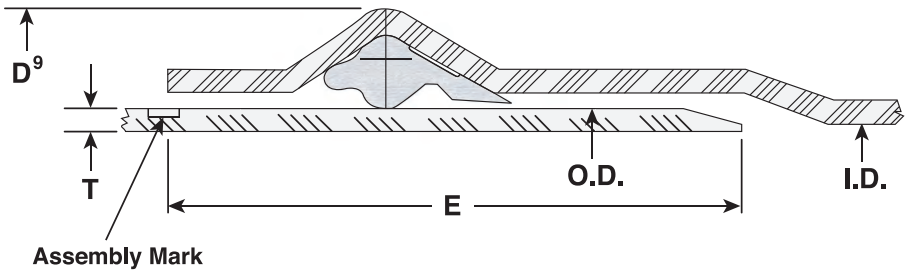
QUALITY • PERFORMANCE • LONGEVITY
50-YEAR WARRANTY on JM Eagle Plastic Pipe
GUARANTEED

BLUE BRUTE™

SUBMITTAL AND DATA SHEET

PIPE SIZE (IN)	AVERAGE O.D. (IN)	NOM. I.D. (IN)	MIN. T. (IN)	MIN. E (IN)	APPROX. D[9] (IN)	APPROX. WEIGHT (LBS/FT)
PRESSURE CLASS 165 psi (DR 25)						
4	4.80	4.39	0.192	5.25	5.57	1.9
6	6.90	6.31	0.276	6.40	8.00	3.9
8	9.05	8.28	0.362	7.05	10.50	6.7
10	11.10	10.16	0.444	8.20	12.88	10.1
12	13.20	12.08	0.528	8.80	15.31	14.4
PRESSURE CLASS 235 psi (DR 18)*						
4	4.80	4.23	0.267	5.25	5.87	2.6
6	6.90	6.09	0.383	6.40	8.43	5.3
8	9.05	7.98	0.503	7.05	11.06	9.2
10	11.10	9.79	0.617	8.20	13.57	13.9
12	13.20	11.65	0.733	8.80	16.13	19.7
PRESSURE CLASS 305 psi (DR 14)*						
4	4.80	4.07	0.343	5.25	6.17	3.2
6	6.90	5.86	0.493	6.40	8.87	6.7
8	9.05	7.68	0.646	7.05	11.63	11.6
10	11.10	9.42	0.793	8.20	14.27	17.6
12	13.20	11.20	0.943	8.80	16.97	25.1

Consult JM Eagle™ for CSA and other listing availability prior to shipment.
Note: *FM Approvals Pressure Class 150 psi for DR 18 and 200 psi for DR 14.



I.D. : Inside Dameter
O.D. : Outside Diameter
T. : Wall Thickness
D[9] : Bell Outside Diameter
E : Distance between Assembly Mark to the end of spigot.

Product Standard:	ANSI/AWWA C900
Pipe Compound:	ASTM D1784 Cells Class 12454 ASTM
Gasket:	F477
Integral Bell Joint:	ASTM D3139
Certifications:	ANSI/NSF Standard 61
	UL Standard 1285
	Pipe Length: 20 feet (+/- 1") laying length
Installation:	AWWA C605
	JM Eagle™ Installation Guide

APPENDIX 4

OCTOBER 2016 SITE VISIT

PHOT0119_LAGOONS.JPG

PHOT0120_LAGOONS.JPG

PHOT0121_LAGOONS.JPG

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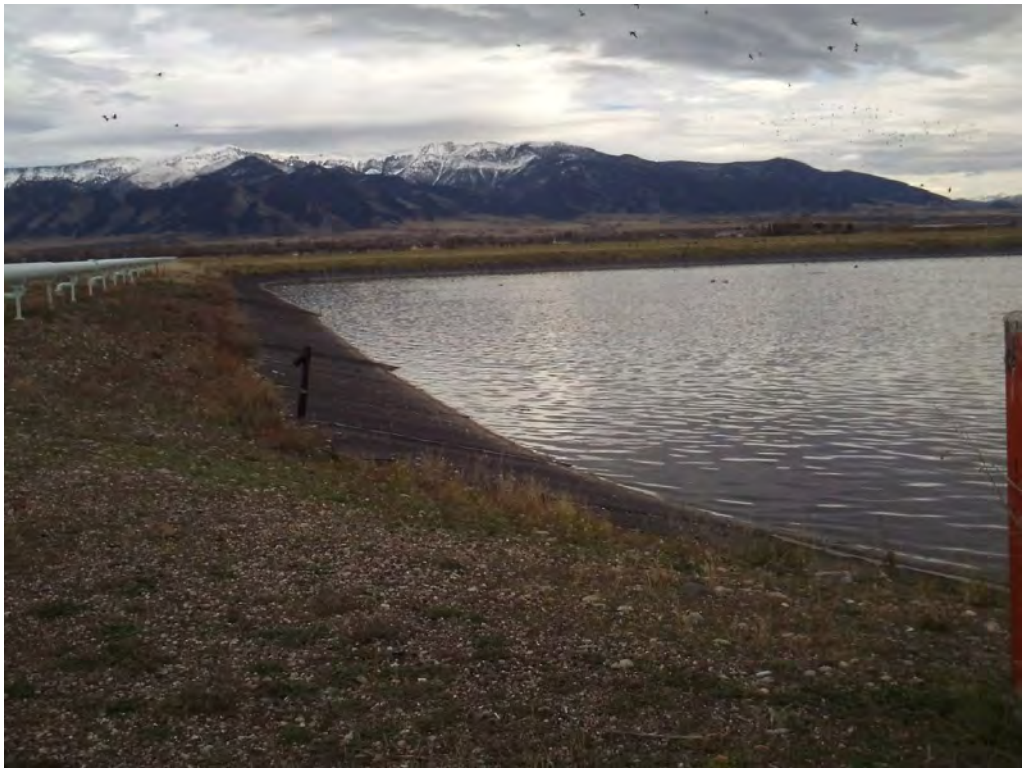

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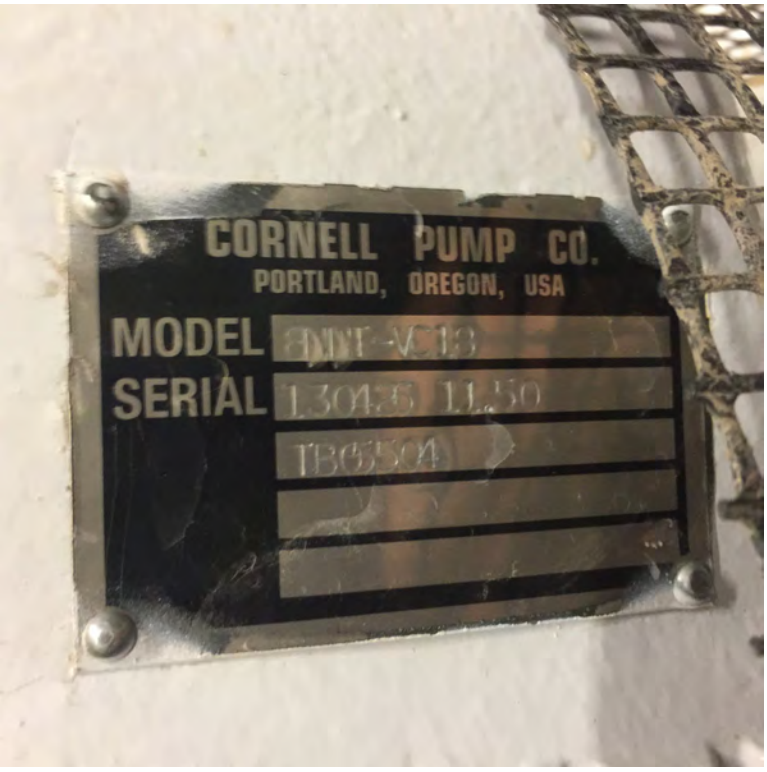

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IMG_4243_PUMP-BUILDING.JPG

Belgrade Lagoon

- 3 or 4 Helixors floated in last couple years
- odors not much last spring
- went to parallel last Dec
  - less odors in the spring
- half of floating aerators in pond 3 Nonfunctional
- air line in the pond 3 is floating
- pond 2 Transducers not functional
- power fluctuation suspected for floating motors
- Need a vactor pump area or pond 1
- Steve has power records
- Look @ floating Air curtains
- Nice to Not have to switch manual valve for A/B I/P switching
- Bad Roof Downspouts
- Mag meters OK
- Irrigation system: Lots of maintenance

TREATMENT PLANT DATA AND FIGURES

Belgrade WWTP Data

	Influent Data- Weir Box											Effluent Data											
Month	Inflow	Ammonia	Total Inorganic Nitrogen	Total Nitrogen	BOD	TSS	Nitrate + Nitrite	Total Kjeldahl Nitrogen	Chloride	Conductivity	Phosphorous	Ammonia	Total Inorganic Nitrogen[1]	Total Nitrogen[1]	BOD	TSS	BOD Removal	TSS Removal	Nitrate + Nitrite	Total Kjeldahl Nitrogen	Chloride	Conductivity	Phosphorous
	gpd	mg/l	mg/L	mg/L	mg/L	mg/L	mg/l	mg/l	mg/l	umhos/cm	mg/l	mg/L	mg/L	mg/L	mg/l	mg/l	%	%	mg/l	mg/l	mg/l	umhos/cm	mg/l
Dec-03					270	262							28.30		21	17	92%	94%					
Jan-04					410	248							30.90		30	19	93%	92%					
Feb-04					380	266							32.48		22	42	94%	84%					
Mar-04					460	412							34.06		18	15	96%	96%					
Apr-04					270	236							32.70		18	31	93%	87%					
May-04					290	260									86	42	70%	84%					
Jun-04					260	276									46	49	82%	82%					
Jul-04					240	216									25	28	90%	87%					
Aug-04					260	256									9	35	97%	86%					
Sep-04					260	236									16	18	94%	92%					
Oct-04					270	207						0.0	10.20	16.00	6	0	98%	100%					
Nov-04					290	2540						2.4	11.93	15.30	6	0	98%	100%					
Dec-04					330	256						1.9	12.70	17.70	16	66	95%	74%					
Jan-05					490	260						10.1	16.92	23.60	43	32	91%	88%					
Feb-05					280	292						16.2	19.38	27.90	14	15	95%	95%					
Mar-05					290	248						17.6	20.00	26.60	12	13	96%	95%					
Apr-05					250	220						16.3	48.51	27.10	29	34	88%	85%					
May-05	568,982				260	238						15.5	18.50	26.30	88	0	66%	100%					
Jun-05	577,377				240	229						12.9	18.50	27.10	43	12	82%	95%					
Jul-05	487,691				260	231						0.0	16.80	21.80	19	33	93%	86%					
Aug-05	No Reading				290	220						3.6	11.00	15.10	6	0	98%	100%					
Sep-05	No Reading				260	135						1.5	6.40	11.20	5	19	98%	86%					
Oct-05	No Reading				290	236						9.4	10.50	17.00	7	14	98%	94%					
Nov-05	No Reading				210	212						2.1	12.90	23.80	59	43	72%	80%					
Dec-05	No Reading				320	199						1.0	12.60	23.70	59	52	82%	74%					
Jan-06	No Reading				330	270						6.0	15.52	23.70	12	34	96%	87%					
Feb-06	No Reading				260	308						10.4	16.33	25.00	12	34	95%	89%					
Mar-06	No Reading				250	220						16.3	18.51	27.00	29	34	88%	85%					
Apr-06	No Reading				350	66						16.2	18.86	27.00	14	24	96%	64%	2.66	24.3	113		
May-06	mputer Down				210	208						16.5	18.28	27.30	29	20	86%	90%	1.78	25.5	120		
Jun-06	401,462				620	360						15.4	18.48	25.80	91	15	85%	96%	3.08				
Jul-06	392,049				300	228						0.0	15.80	20.50	21	0	93%	100%	15.80				
Aug-06	397,156				400	235						1.1	14.80	21.50	13	14	97%	94%	13.70				
Sep-06	466,362				270	208						0.6	10.60	16.30	15	22	94%	89%	10.00	6.3			
Oct-06	423,358				220	226						0.4	12.80	18.50	6	11	97%	95%	21.40				
Nov-06	463,608				260	295						0.8	10.30	16.80	4	0	98%	100%	10.30				
Dec-06	441,231				230	336						4.1	14.20	19.60	12	0	95%	100%	10.10				
Jan-07	mputer Down				270	78						8.5	17.40	17.40	8	0	97%	100%	8.91				
Feb-07	484,921				320	268						14.8	21.66	21.66	10	0	97%	100%	6.86				
Mar-07	463,552				280	294						20.1	24.47	24.47	9	0	97%	100%	4.19				
Apr-07	463,652				260	280						21.8	25.72	25.72	13	0	95%	100%	3.92				
May-07	416,246				250	264						23.8	19.12	29.12	98	12	61%	95%	5.32				
Jun-07	No Reading				320	226						0.0	22.60	22.60	19	27	94%	88%					
Jul-07	No Reading				320	226						0.0	22.20	22.20	11	27	97%	88%	22.20	4.1	116		
Aug-07	366,667				240	235						1.3	16.10	16.10	4	12	98%	95%	14.80				
Sep-07	590,096				260	247						0.3	11.70	11.70	5	0	98%	100%	11.40				
Oct-07	569,881				250	264						0.0	4.70	4.70	<4	10		96%	4.70	4.9	140		
Nov-07	579,261				250	257						0.9	1.50	4.51	5	13	98%	95%	3.61				
Dec-07	605,973				320	300						1.3	23.30	23.30	6	0	98%	100%	22.00	3.0	49		
Jan-08	618,617				290	229						9.4	11.95	11.95	10	0	97%	100%	2.55	17.1	414		
Feb-08	631,878				200	261						19.1	22.06	22.06	11	10	95%	96%	2.96	25.7	126		
Mar-08	609,505				260	291						23.5	24.52	24.52	13	0	95%	100%	1.02				
Apr-08	578,787				270	285						24.0	24.73	24.73	14	0	95%	100%	0.73	26.6	125		
May-08	545,232				240	258						26.8	27.53	28.53	25	18	90%	93%	0.73		114		
Jun-08	585,673				1800	1490						4.3	19.70	19.70	48	33	97%	98%	15.40				
Jul-08	535,158				220	262						3.6	19.00	19.00	37	12	83%	95%	15.40				
Aug-08	520,056				300	284						1.6	12.80	12.80	6	12	98%	96%	11.20	4.6	126		

Month	Influent Data- Weir Box											Effluent Data											
	Inflow	Ammonia	Total Inorganic Nitrogen	Total Nitrogen	BOD	TSS	Nitrate + Nitrite	Total Kjeldahl Nitrogen	Chloride	Conductivity	Phosphorous	Ammonia[1]	Total Inorganic Nitrogen[1]	Total Nitrogen[1]	BOD	TSS	BOD Removal	TSS Removal	Nitrate + Nitrite	Total Kjeldahl Nitrogen	Chloride	Conductivity	Phosphorous
	gpd	mg/l	mg/L	mg/L	mg/L	mg/L	mg/l	mg/l	mg/l	umhos/cm	mg/l	mg/L	mg/L	mg/L	mg/l	mg/l	%	%	mg/l	mg/l	mg/l	umhos/cm	mg/l
Sep-08	613,446				200	216						0.7	9.15	9.15	7	0	97%	100%	8.45	3.6	130		
Oct-08	584,158				290	154						0.3	5.39	5.39	4	0	99%	100%	4.96				
Nov-08	545,629				260	300						1.7	6.66	6.66	5	13	98%	96%	4.96				
Dec-08	567,548				230	230						6.7	10.14	10.14	17	0	93%	100%	3.44				
Jan-09	561,566				360	260						19.8	21.04	21.04	18	15	95%	94%	12.40		136		
Feb-09	570,784				280	314						29.0	29.60	29.60	21	20	93%	94%	0.60	34.0	141		
Mar-09	575,639				350	502						32.0	32.36	32.36	18	22	95%	96%	0.36	44.0	146		
Apr-09	553,374				270	316						32.5	32.87	32.87	15	29	94%	91%	0.37	34.0	109		
May-09	494,113				310	266						20.8	27.36	27.36	20	64	94%	76%	6.56	23.0	123		
Jun-09	543,133				240	228						1.3	21.40	21.40	28	27	88%	88%	20.10				
Jul-09	No Reading				260	264						0.3	16.10	16.10	20	17	92%	94%	15.80	1.8	130		
Aug-09	No Reading				280	282						2.0	12.78	12.78	37	13	87%	95%	10.80	3.8	136		
Sep-09	No Reading				170	222						2.5	7.13	7.13	14	11	92%	95%	4.63	5.7	142		
Oct-09	No Reading				300	213						0.4	1.23	1.23	6	11	98%	95%	0.80				
Nov-09	No Reading				220	268						1.9	3.82	3.82	<6	0		100%	1.95	4.1	147		
Dec-09	No Reading				260	182						4.3	7.02	7.02	10	0	96%	100%	2.72	8.4	147		
Jan-10	No Reading				250	257						8.4	11.08	11.08	6	0	98%	100%					
Feb-10	No Reading				350	276						23.2	24.60	24.60	17	31	95%	89%	1.04	32.1	152		
Mar-10	418,870				360	126						34.7	25.23	35.23	17	27	95%	79%	0.53	37.0	146		
Apr-10	413,833				220	224						28.1	28.52	28.52	18	21	92%	91%	0.42	28.0	123		
May-10	465,161				240	185						29.4	31.95	31.95	>95	31		83%	2.55	27.0	121		
Jun-10	452,333				170	218						19.3	29.50	29.50	61	10	64%	95%	10.20	17.0			
Jul-10	488,419				93	100						0.8	23.02	23.02	21	11	77%	89%	22.20	4.2	128		
Aug-10	444,677				290	302						2.1	17.10	17.10	13	0	96%	100%	15.00	0.8	135		
Sep-10	537,000				280	228						1.7	11.18	11.18	6	16	98%	93%	9.47	6.5	137		
Oct-10	436,612				330	237						3.0	5.71	5.71	<6	11		95%	2.71	5.9	142		
Nov-10	500,166				250	228						3.8	6.11	6.11	23	13	91%	94%	2.31	7.1	139		
Dec-10					250	257						8.4	11.08	11.08	6	0	98%	100%	2.68	12.1	126		
Jan-11					250	237						17.3	19.50	19.50	12	0	95%	100%	2.78	19.0	143		
Feb-11					190	229						25.4	26.70	26.70	13	16	93%	93%	1.30	26.0	139		
Mar-11																							
Apr-11																							
May-11																							
Jun-11																							
Jul-11																							
Aug-11																							
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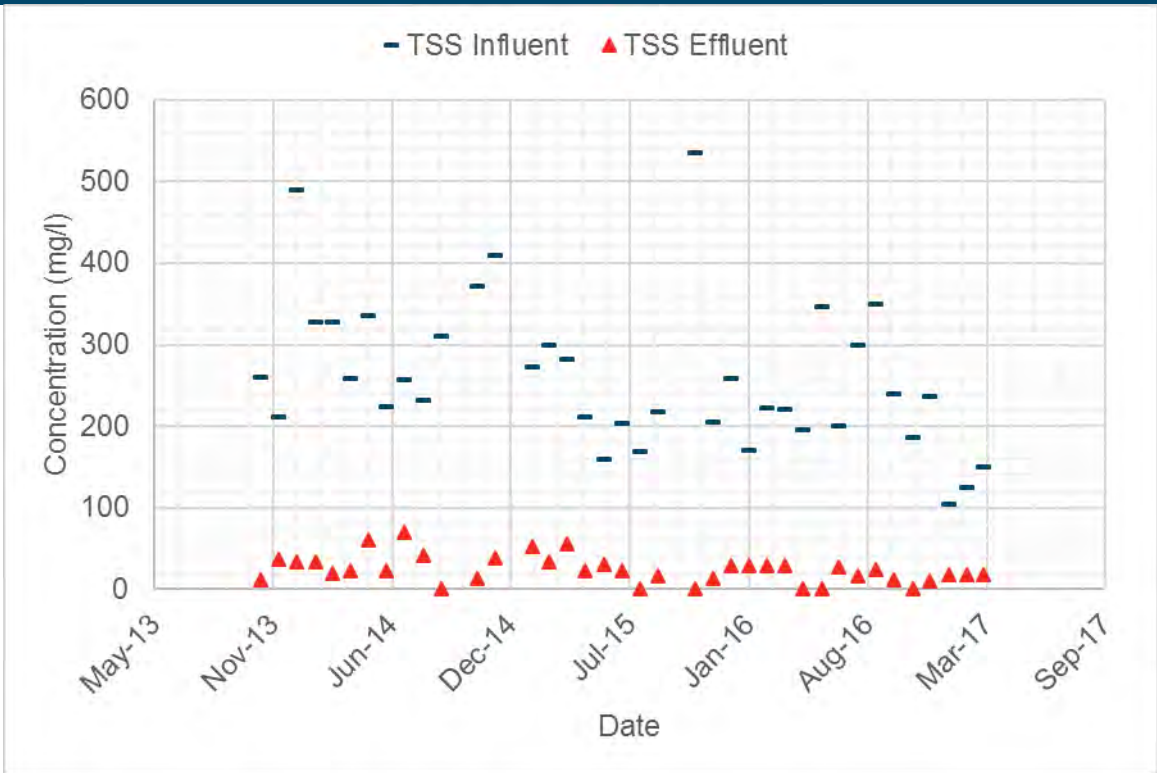
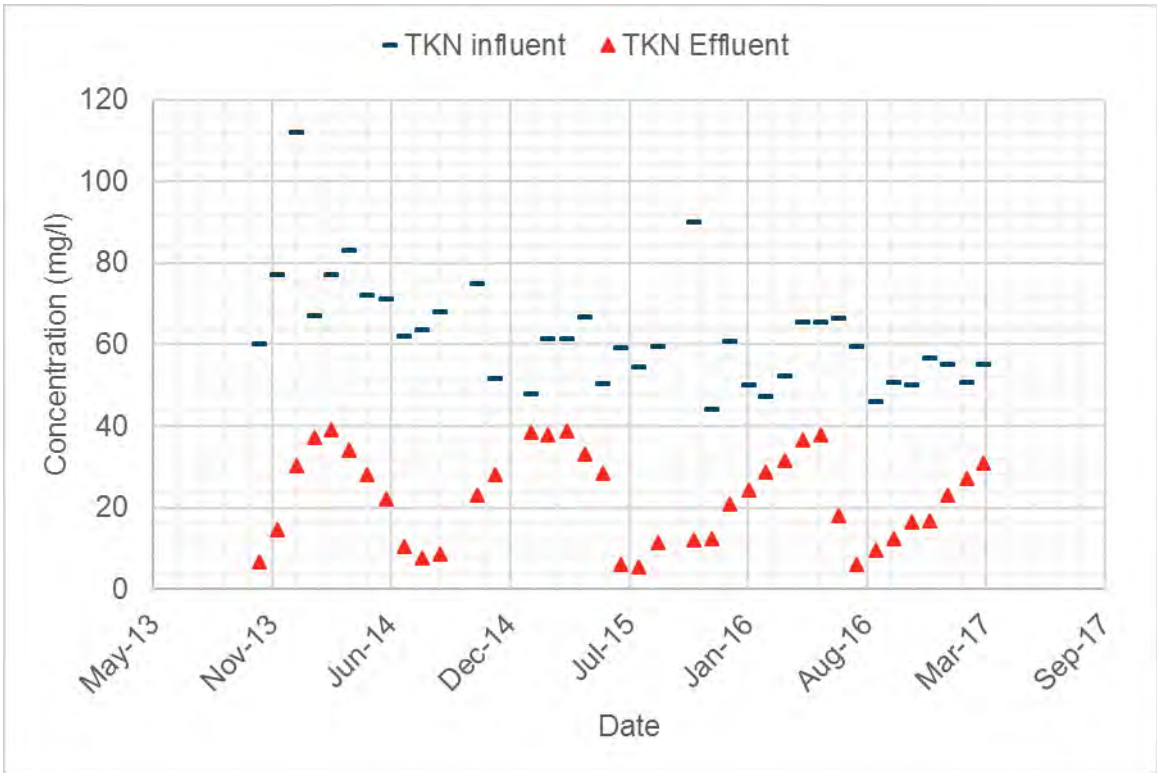
Mar-13																							
Apr-13																							
May-13																							
Jun-13																							

Month	Influent Data- Weir Box											Effluent Data											
	Inflow	Ammonia	Total Inorganic Nitrogen	Total Nitrogen	BOD	TSS	Nitrate + Nitrite	Total Kjeldahl Nitrogen	Chloride	Conductivity	Phosphorous	Ammonia[1]	Total Inorganic Nitrogen[1]	Total Nitrogen[1]	BOD	TSS	BOD Removal	TSS Removal	Nitrate + Nitrite	Total Kjeldahl Nitrogen	Chloride	Conductivity	Phosphorous
	gpd	mg/l	mg/L	mg/L	mg/L	mg/L	mg/l	mg/l	mg/l	umhos/cm	mg/l	mg/L	mg/L	mg/L	mg/l	mg/l	%	%	mg/l	mg/l	mg/l	umhos/cm	mg/l
Jul-13																							
Aug-13																							
Sep-13																							
Oct-13																							
Nov-13		41.0		60.4	270	260	0.26	60.1	50	992	7.22	2.5		8.60	7	11	97%	96%	1.99	6.6	145	1060	5.63
Dec-13		24.0		77.2		212	0.22	77.0	38	1010	9.50	7.7		17.10		37		83%	2.62	14.5	146	1140	6.33
Jan-14		29.0		113.0		490	0.72	112.0	154	1280	17.80	21.5		31.60		34		93%	1.34	30.3	149	1250	6.62
Feb-14		31.8		67.0	637	327	0.26	67.0	65	1010	9.60	28.5		38.00	15	34	98%	90%	0.65	37.3	142	1280	6.48
Mar-14		33.0		77.0	530	327	0.42	77.0	160	1380	11.20	34.0		39.00	17	20	97%	94%	0.33	39.0	138	1250	6.42
Apr-14		38.0		83.0	230	258	0.45	83.0	579	2680	7.90	31.0		34.00	19	22	92%	91%	0.25	34.0	114	1030	5.15
May-14		35.0		73.0	280	336	0.53	72.0	65	1120	9.70	24.0		30.00	45	61	84%	82%	1.53	28.0	116	1030	6.09
Jun-14		38.0		71.0		224	0.27	71.0	55	992	7.80	13.0		32.30		23		90%	10.20	22.1	134	1060	7.20
Jul-14		36.0		62.0	310	257	0.22	62.0	66	1080	8.40	0.4		25.90	18	70	94%	73%	15.50	10.4	142	1040	7.90
Aug-14		45.1		63.7	220	232	0.16	63.5	151	1390	8.17	1.8		13.70	13	41	94%	82%	6.13	7.6	154	1100	7.57
Sep-14		39.4		68.0	350	310	0.12	68.0	62	1120		6.1		8.60	10	0	97%	100%	ND	8.6	148	1160	
Oct-14																							
Nov-14		42.0		75.2		372	0.21	75.0	54	1070	8.55	18.2		23.50		13		97%	0.60	22.9	149	1220	6.33
Dec-14		39.0		51.6	880	410	0.14	51.5	90	1120	6.83	23.3		30.40	43	38	95%	91%	2.43	28.0	151	1200	5.88
Jan-15																							
Feb-15		30.2		48.1		272	0.30	47.8			6.20	32.5		39.40		52		81%	0.80	38.6	141		5.96
Mar-15		32.7		62.0		299	0.49	61.5			6.65	34.0		38.50		33		89%	0.68	37.8	117		5.40
Apr-15		27.7		62.1		282	0.58	61.5			7.55	30.5		39.60		55		80%	0.77	38.8	129		6.05
May-15		28.9		67.0		211	0.20	66.8			9.20	26.5		36.30		22		90%	3.12	33.2			6.50
Jun-15		30.2		50.5		160	0.14	50.4			5.69	20.8		32.60		31		81%	4.23	28.4	136		
Jul-15		42.6		59.3		204	0.11	59.2			7.01	1.3		14.70		22		89%	8.48	6.2	144		7.28
Aug-15		32.6		54.5	370	169	0.12	54.4	201	1500	6.75	2.1		8.10	<6	0	100%	100%	2.52	5.6	154	1140	6.60
Sep-15		40.5		59.5		218	0.06	59.4			6.96	7.5		12.00		17		92%	0.53	11.5	159		8.30
Oct-15																							
Nov-15		32.0		90.4		535	0.45	90.0			13.10	8.3		13.00		0		100%	0.86	12.1	158		6.32
Dec-15				44.4		205	0.37	44.0			5.21			14.90		13		94%	2.44	12.5	171		6.04
Jan-16		31.0		61.2		258	0.35	60.8			8.16	14.0		22.80		29		89%	1.99	20.8	163		5.84
Feb-16		25.5		50.6		170	0.41	50.2			5.81	19.4		25.40		29		83%	1.18	24.2	158		8.95
Mar-16		25.1		51.3		222	4.13	47.2			11.20	22.0		29.40		29		87%	0.80	28.6	152		5.60
Apr-16		26.1		52.9		220	0.49	52.4			6.30	24.0		32.00		29		87%	0.44	31.6	146		5.39
May-16		36.6		69.0		196	3.37	65.6			12.80	29.0		36.60		0		100%	0.20	36.6	148		6.22
Jun-16		29.1		65.7		347	0.08	65.6			7.70	29.8		38.70		0		100%	0.78	37.9	150		6.38
Jul-16		38		66.5		200	0.1	66.4			6.10	9.6		29.7		27		87%	11.6	18.1	160		6.8
Aug-16		39		59.6		300	0.02	59.6			7.69	2.2		15.2		17		94%	9.2	6	159		7.09
Sep-16		29.9		47		349	0.07	46.0			6.32	4.0		14.7		24		93%	5.33	9.4	180		6.01
Oct-16		39		50.9		240	0.8	50.8			6.29	6.5		16		11		95%	3.75	12.3	168		6.83
Nov-16		39.8		50.1		186	0.08	50.0			6.59	12.2		18.5		0		100%	2.24	16.3	158		6.49
Dec-16		37.1		56.7		236	0.09	56.6			7.39	12.1		19.9		10		96%	3.15	16.7	155		6.42
Jan-17		30.3		56.2		104	0.95	55.2			8.13	17.4		25.8		18		83%	2.55	23.2	165		6.47
Feb-17		30		51.3		125	0.47	50.85			7.16	24.3		28.7		18		86%	1.67	27	163		6.22
Mar-17		35.6		55.7		150	0.47	55.2			6.83	29.1		31.8		18		88%	1.08	30.8	167		6.19
Apr-17		40.1		61.8		172	0.21	61.6			7.58	29.8		32.9		27		84%	0.72	32.2	150		5.9
May-17		34		60.1		248	0.12	60			7.55	22		33		32		87%	5.82	27.2	149		5.9

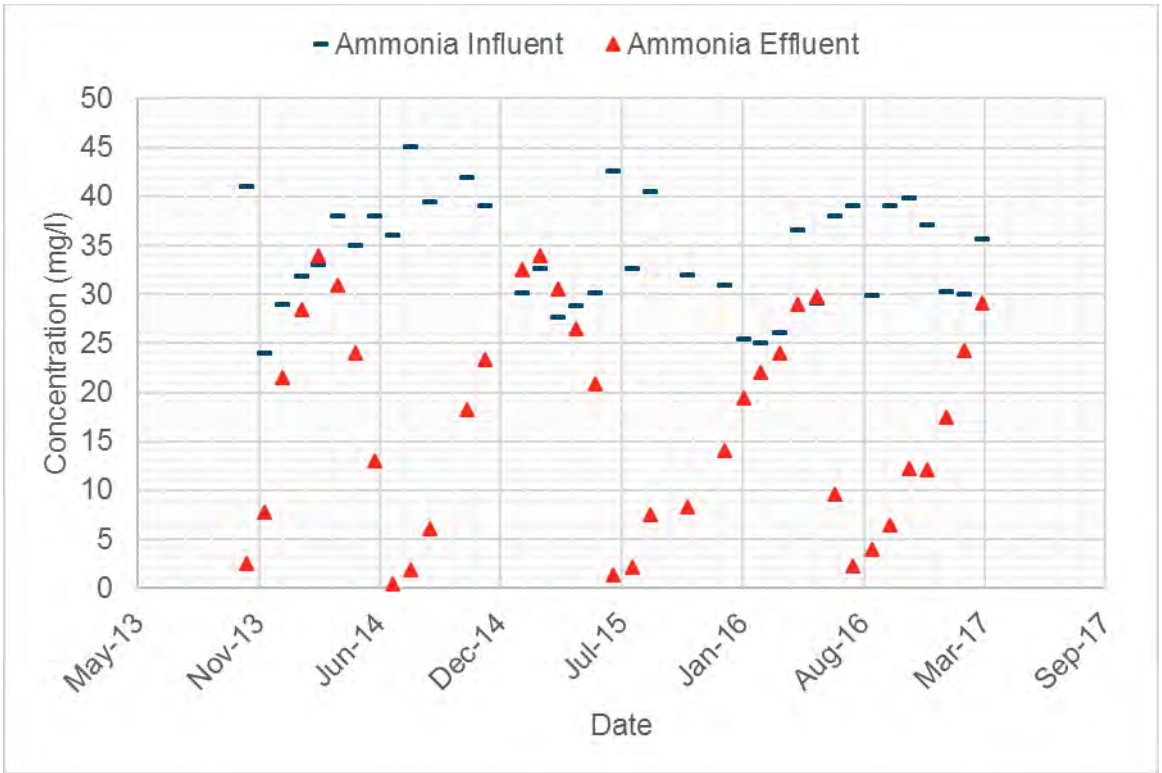
BWTP Contaminant Influent and Effluent Concentrations



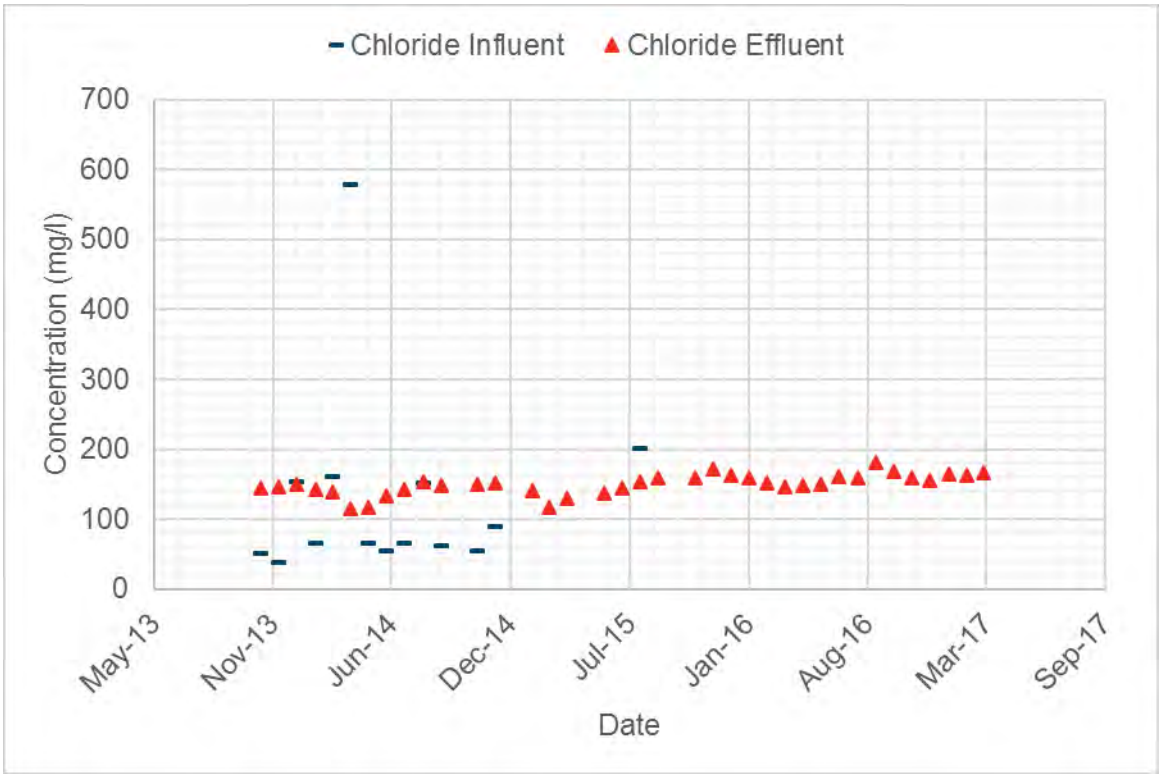
BWTP Total Suspended Solids (TSS) Influent and Effluent Concentrations



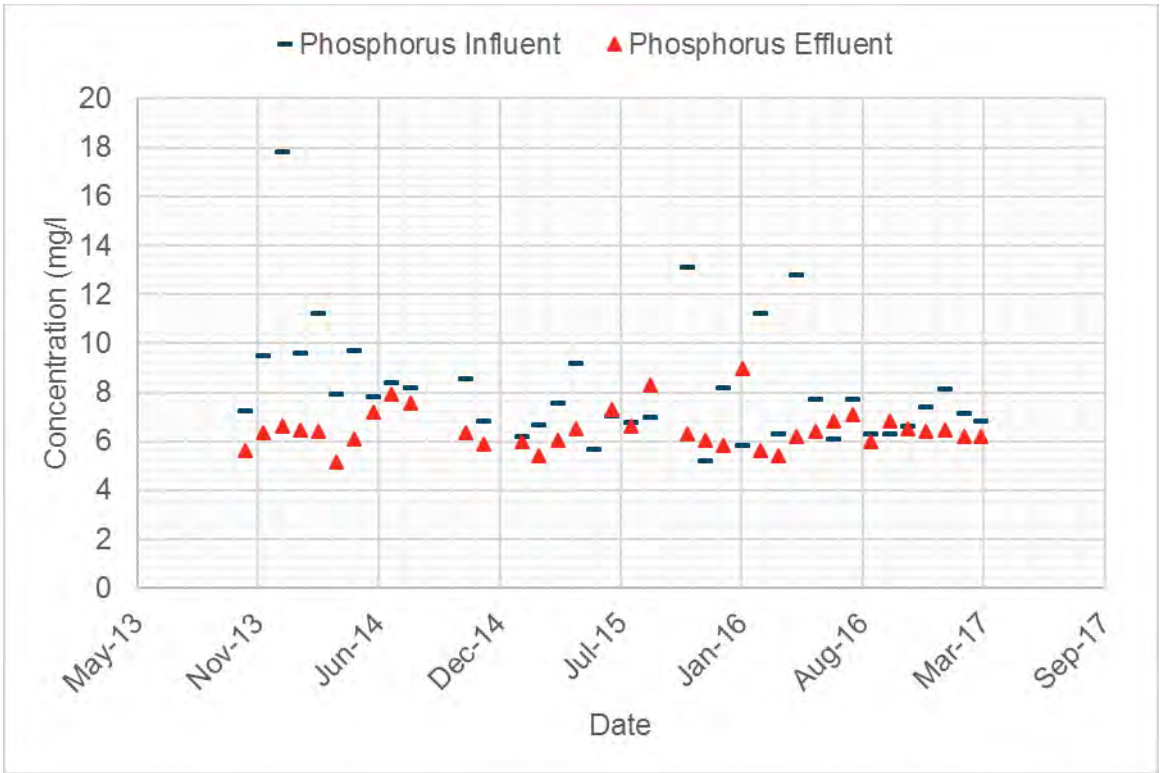
BWTP TKN Influent and Effluent Concentrations



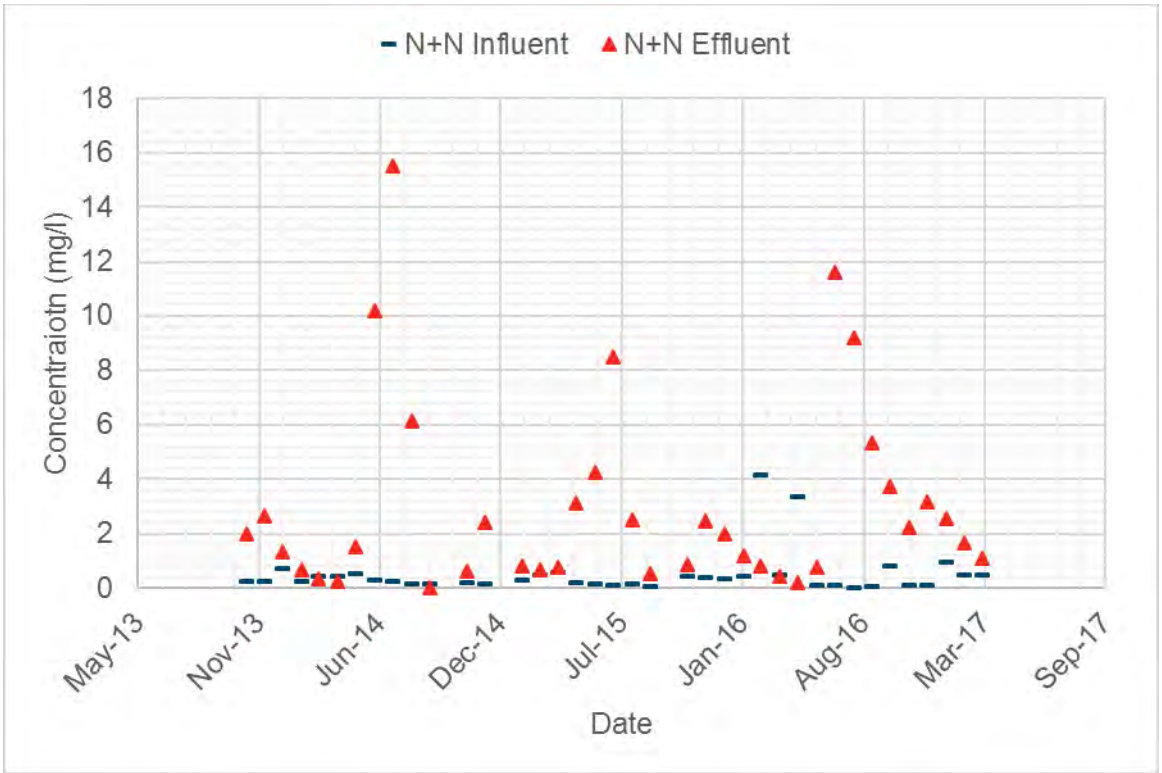
BWTP Ammonia Influent and Effluent Concentrations



BWTP Chloride Influent and Effluent Concentrations

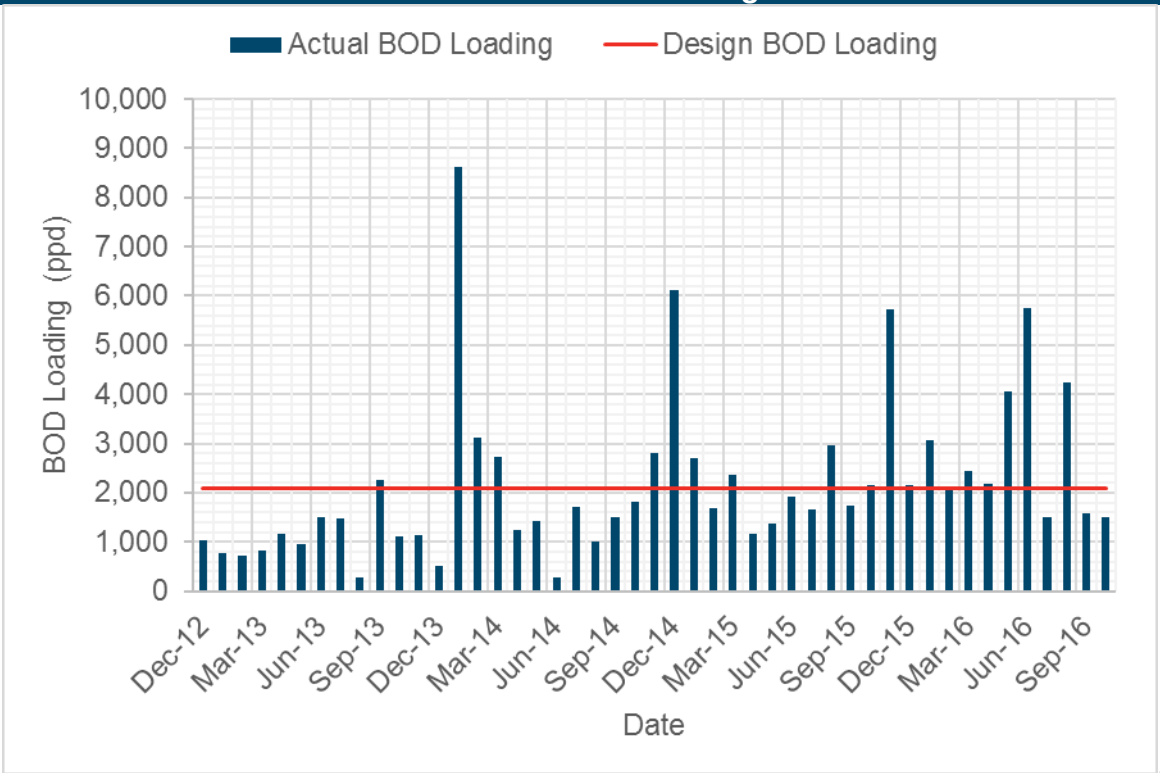


BWTP Total Phosphorus Influent and Effluent Concentrations

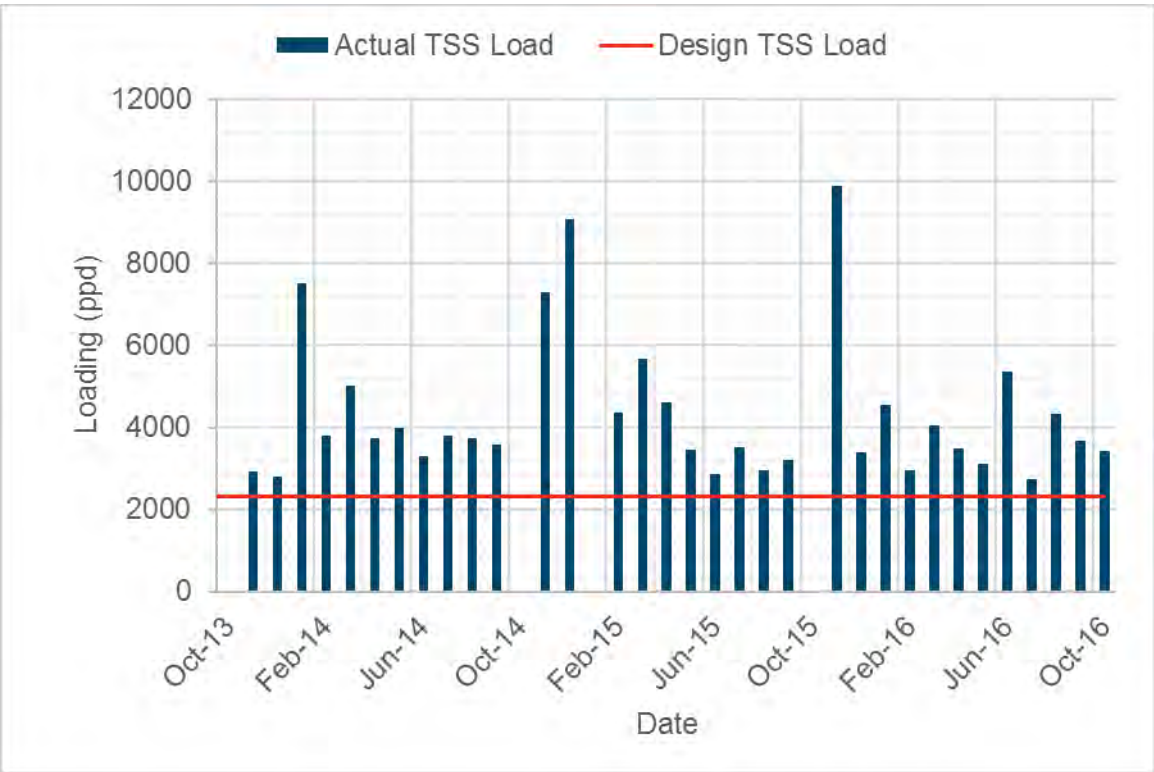


BWTP Nitrate +Nitrites (as N) Influent and Effluent Concentrations

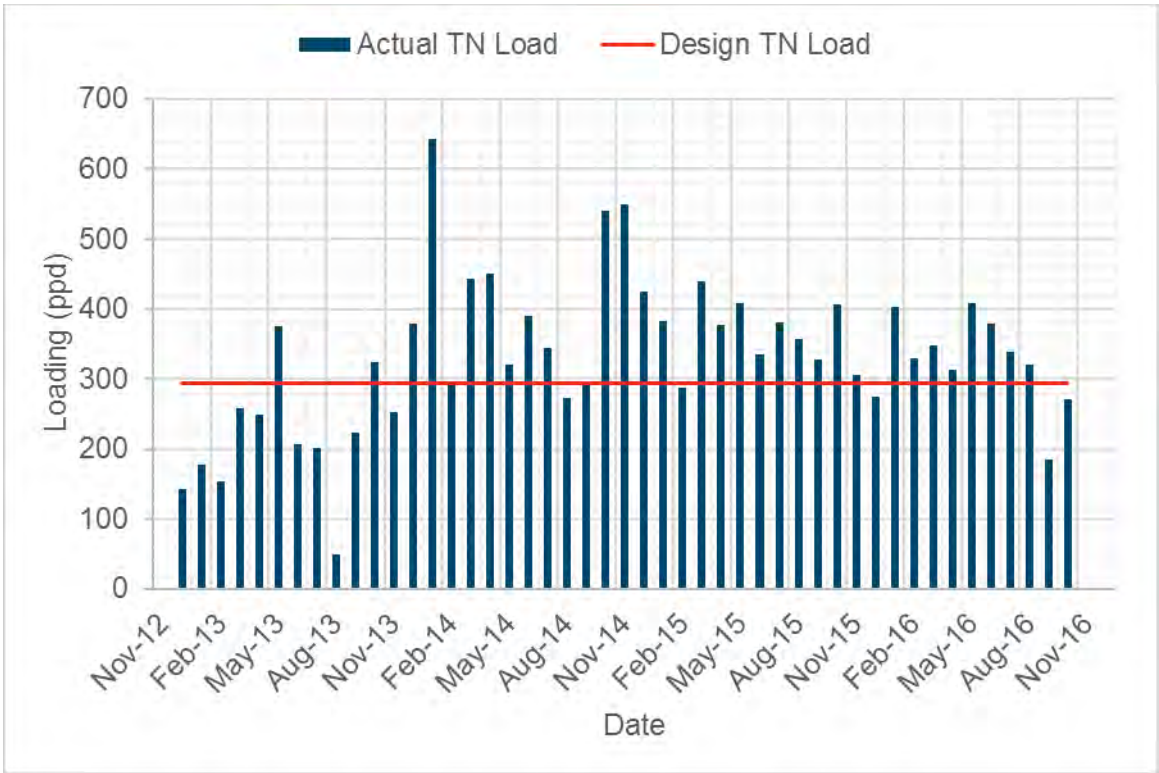
BWTP Influent Loading



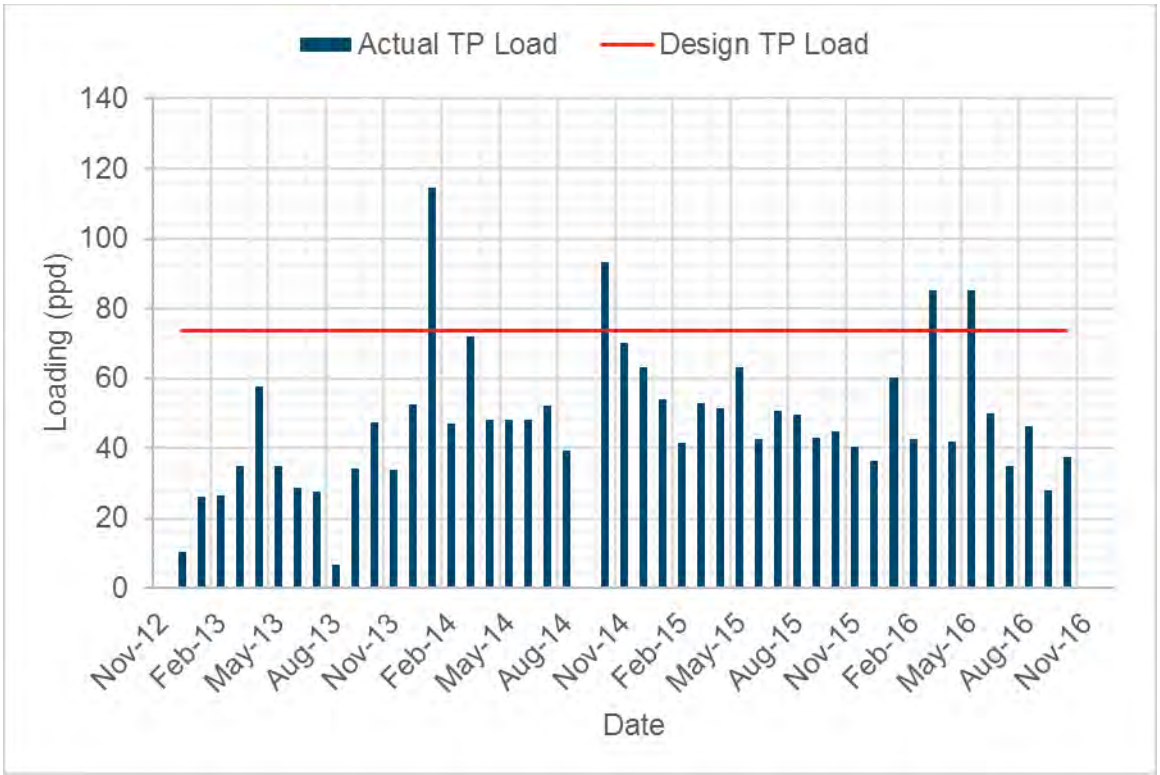
BWTP BOD Loading



BWTP TSS Loading



BWTP Total Nitrogen Loading



BWTP Total Phosphorus Loading

Monitoring Wells Summary
Conductivity (umhos.cm)
2002 to 2016

Month	Year	1A	2A	3A	4A	5A	6A	1B	2B	3B	4B	5B	6B	1C	2C	3C	4C	5C	6C
January	2002																		
February	2002																		
March	2002																		
April	2002																		
May	2002																		
June	2002																		
July	2002																		
August	2002																		
September	2002																		
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April	2009																		
May	2009																		
June	2009																		
July	2009																		
August	2009																		

September	2009	600.0													411.0					
October	2009	573.0																		
November	2009	540.0																		
December	2009	510.0													442.0					
January	2010	503.0																		
February	2010	484.0																		
March	2010	480.0													409.0					
April	2010	483.0																		
May	2010	493.0																		
June	2010	474.0													361.0					
July	2010	480.0																		
August	2010	538.0																		
September	2010	566.0													384.0					
October	2010	555.0																		
November	2010	544.0																		
December	2010	548.0													428.0					
January	2011	493.0																		
February	2011																			
March	2011																			
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April	2013																			
May	2013																			

June	2013																		
July	2013																		
August	2013																		
September	2013																		
October	2013						650						553						446
November	2013																		
December	2013	500.0		691.0		686.0	706				619	648	575	404.0		503.0		484.0	485
January	2014						709						581						459
February	2014						746						570						485
March	2014	445.0		707.0		709.0	712				628	625	575	384.0		620.0		332.0	350
April	2014						695						552						439
May	2014						631						532						379
June	2014	283.0		576.0		617.0	620				570	573	550	396.0		418.0		404.0	403
July	2014						594						551						406
August	2014						582						563						406
September	2014	488.0		435.0		496.0	555				579	623	578	410.0		416.0		411.0	407
October	2014						608						582						415
November	2014						699						604						524
December	2014	525.0		657.0		652.0	711				652	640	587	437.0		520.0		534.0	535
January	2015						716						587						508
February	2015						711						572						469
March	2015						605						559						468
April	2015						649						555						470
May	2015						629						553						362
June	2015	394.0		552.0		613.0	625				568	593	550	380.0		423.0		419.0	418
July	2015						623						566						407
August	2015						680						599						409
September	2015																		
October	2015						679						599						107
November	2015						726						594						497
December	2015																		
January	2016						774						607						479
February	2016						754						603						507
March	2016						771						581						484
April	2016						772						570						503
May	2016						753						566						483
June	2016						740						548						391
July	2016						700						541						375
August	2016						702						556						381
September	2016						669						573						383
October	2016						664						557						374
November	2016						679						565						491
December	2016						688						564						466
January	2017						686						564						432
February	2017						680						564						433
March	2017						657						561						492
April	2017						658						563						480
May	2017																		

Monitoring Wells Summary
Chloride Concentration (mg/L)
2002 to 2016

Month	Year	1A	2A	3A	4A	5A	6A	1B	2B	3B	4B	5B	6B	1C	2C	3C	4C	5C	6C
January	2002							7	21	11	38	21							
February	2002																		
March	2002							7	31	9	41	37							
April	2002																		
May	2002																		
June	2002							6	35	11	47	34							
July	2002																		
August	2002							11	13	8	29	26							
September	2002							10	17	7	19	29							
October	2002							9	13	6	16	33							
November	2002							8	38	6	24	22							
December	2002							8	10	8	32	18							
January	2003		61	42	13	48		7	32	6	20	11		2	49	9	6	11	
February	2003							7	19	9	30	23							
March	2003							7	30	11	38	25		4	36	11	9	12	
April	2003								20	10	44	33							
May	2003								10	8	33	22							
June	2003	8	66	26	10	42			11	8	28	14		3	8	6	7	7	
July	2003								16	8	25	15							
August	2003								18	8	25	15							
September	2003	9	48	21	9	39			16	10	25	14		3	5	3	5	6	
October	2003								14	8	24	12							
November	2003								86	10	67	32							
December	2003	6	128	28	8	46			40	10	50	47		3	4	3	4	4	
January	2004								8	7	19	12							
February	2004								18	6	25	24							
March	2004	5	83	47	8	54			9	6	24	30							
April	2004								11	19	6	21							
May	2004								9	6	19	17							
June	2004	33	26	22	25	25			8	6	13	12							
July	2004								13	5	12	11							
August	2004								14	5	12	12							
September	2004	9	14	11	7	19			15	6	14	13							
October	2004								14	7	18	13							
November	2004								26	9	56	14							
December	2004	10	111	33	8	37			23	8	28	17							
January	2005																		
February	2005																		
March	2005	5	12	12	7	26			9	6	13	11		3	5	5	4	4	
April	2005	6	11	9	7	17			7	6	11	9							
May	2005	7	19	14	6	14			7	6	10	7							
June	2005																		
July	2005																		
August	2005																		

September	2005																		
October	2005																		
November	2005																		
December	2005																		
January	2006																		
February	2006																		
March	2006																		
April	2006	5	36	29	9	32			8	8	23	14							
May	2006	5	24	18	8	31			9	7	18	10							
June	2006																		
July	2006																		
August	2006	7	15	12	6	26			30	6	13	26							
September	2006	9	12	10	6	20								5	5	5	4	5	
October	2006																		
November	2006																		
December	2006																		
January	2007	8	119	25	10	23			8	7	14	9							
February	2007																		
March	2007																		
April	2007																		
May	2007																		
June	2007	12	45	20	7	28			18	5	10	8		4	12	10	5	10	
July	2007																		
August	2007	30	12	11	7	16			28	6	15	56							
September	2007																		
October	2007	27	18	16	10	14			30	10	27	36							
November	2007								ND	ND	ND	ND							
December	2007	19	28	21	14	19			15	13	34	16		5	6	5	5	6	
January	2008	11	132	29	16	23			11	13	34	11							
February	2008	10	129	47	16	27			10	12	32	10							
March	2008	11	81	53	17	42			9	11	29	10		4	55	18	8	17	
April	2008																		
May	2008																		
June	2008	22	28	21	11	39			22	8	17	14		5	10	9	6	8	
July	2008	32	21	14	10	27			31	7	13	22							
August	2008	25	18	14	11	21			28	7	14	27							
September	2008																		
October	2008																		
November	2008																		
December	2008																		
January	2009	13	37	26	21	29			53	19	62	32							
February	2009	12	37	22	21	30			46	21	74	38							
March	2009	13	28	17	18	27			28	17	59	33		4	11	27	8	13	
April	2009	14	29	13	15	23			45	14	51	33							
May	2009																		
June	2009																		
July	2009	23	17	11	11	15			20	9	16	16							
August	2009	25	18	11	12	15			24	10	16	17							

September	2009	33	19	14	13	16				38	10	16	26			4	10	4	8	10	
October	2009	26	22	18	16	18				40	11	20	36								
November	2009	22	25	21	17	20				35	13	25	35								
December	2009	16	165	46	20	31				44	17	53	39			4	50	32	11	28	
January	2010	12	36	37	20	42				21	17	39	24								
February	2010	12	33	31	19	39				22	16	36	22								
March	2010	11	49	20	15	28				17	15	27	15			4	24	21	11	18	
April	2010	10	37	28	14	27				14	14	26	15								
May	2010	10	64	17	11	20				13	13	21	14								
June	2010	10	29	19	10	28				21	13	20	14			3	8	11	5	9	
July	2010	18	24	12	10	26				32	13	20	23								
August	2010	22	16	9	10	17				43	12	18	32								
September	2010	25	124	25	12	16				51	14	22	41			5	9	5	6	8	
October	2010	20	36	31	12	25				49	13	25	45								
November	2010	21	46	23	14	33				47	15	32	44								
December	2010	15	130	28	16	32				41	16	36	43			5	53	27	10	27	
January	2011	10	131	30	16	42				27	17	40	32								
February	2011	9	142	36	15	45				20	17	37	22								
March	2011																				
April	2011																				
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June	2013																		
July	2013																		
August	2013																		
September	2013																		
October	2013						46						14						15
November	2013																		
December	2013	16		61		58	56				35	36	20	5		25		24	24
January	2014						61						22						20
February	2014						70						19						23
March	2014	6		54		57	61				34	27	15	3		40		14	14
April	2014						53						13						13
May	2014						38						11						6
June	2014	2		25		32	32				20	16	11	4		6		7	7
July	2014						27						13						7
August	2014						23						14						6
September	2014	21		7		11	18				17	25	17	4		4		6	6
October	2014						31						22						8
November	2014						34						15						13
December	2014	17		50		45	55				37	31	21	5		17		26	5
January	2015						55						21						20
February	2015						46						15						13
March	2015	9		29		40	29				30	19	13	4		13		14	14
April	2015						35						12						14
May	2015						32						11						7
June	2015	16		24		31	33				19	22	15	3		6		10	10
July	2015						34						19						9
August	2015						43						22						8
September	2015	21		19		32	47				31	35	24	4		5		10	10
October	2015						49						27						10
November	2015						64						26						25
December	2015	26		50		60					56	49		4		20		21	
January	2016						76						28						22
February	2016						66						23						26
March	2016	10		53		65	70				45	28	19	3		24		19	19
April	2016						71						17						23
May	2016						64						16						18
June	2016	4		36		51	62				30	22	15	3		10		7	7
July	2016						54						14						5
August	2016						49						15						5
September	2016	37		34		49	45				24	31	18	3		4		5	5
October	2016						48						19						5
November	2016						51						19						25
December	2016	20		52		58	53				37	33	18	4		18		20	20
January	2017						56						19						14
February	2017						52						18						14
March	2017	7		57		54	45				41	26	16	4		21		22	22
April	2017						45						15						19
May	2017																		

Monitoring Wells Summary																			
Nitrate+Nitite Concentration (mg/L)																			
2002 to 2016																			
Month	**Year**	**1A**	**2A**	**3A**	**4A**	**5A**	**6A**	**1B**	**2B**	**3B**	**4B**	**5B**	**6B**	**1C**	**2C**	**3C**	**4C**	**5C**	**6C**
January	2002							1.06	1.75	1.11	1.79	1.9							
February	2002										.								
March	2002							1.11	2.7	1.02	1.47	2.16							
April	2002																		
May	2002																		
June	2002							1.1	9.04	0.93	1.88	8.47							
July	2002																		
August	2002							1.14	1.5	0.98	1.66	2.82							
September	2002							1.19	1.61	1	1.73	2.38							
October	2002							1.18	1.51	1.01	1.77	2.14							
November	2002							1.14	10.6	1.23	6.32	4.15							
December	2002							1.22	2.24	1.69	6.84	4.22							
January	2003							1.3	3.86	1.01	2.09	2.4		0.85	1.10	0.92	0.90	1.03	
February	2003							1.31	2.58	0.96	2.67	3.55							
March	2003		1.09	1.80	1.20	0.48		1.33	4.5	0.95	2.65	3.51		0.75	0.95	0.87	0.91	1.11	
April	2003								3.4	1.03	3.28	5.1							
May	2003								1.85	0.94	1.93	4.91							
June	2003	1.70	3.20	2.09	1.24	0.64			1.66	0.99	1.24	2.42		0.81	1.14	0.82	0.89	0.87	
July	2003								1.76	0.99	1.61	1.81							
August	2003								1.77	1.08	2.9	1.57							
September	2003	1.34	1.67	1.36	1.29	0.63			1.7	1.1	2.25	1.43		0.80	0.94	0.82	0.79	0.91	
October	2003								1.49	1.05	2.42	1.29							
November	2003								5.56	1.61	6.14	4.31							
December	2003	1.24	2.73	1.63	1.30	1.32			3.34	1.75	5.5	4.8		0.83	0.96	0.79	0.77	0.88	
January	2004								1.3	1.1	1.8	1.63							
February	2004								2.55	0.98	3.95	3.64							
March	2004	1.40	0.80	3.40	1.30	1.16			1.8	1	2.7	3.11							
April	2004								6	1	2.7	3.79							
May	2004								2.98	1.18	5.7	8.1							
June	2004	1.30	17.60	3.70	1.40	1.58			2.1	1.1	2.9	3.86							
July	2004								2.63	0.93	3.42	2.64							
August	2004								2.29	1.15	3.79	2.17							
September	2004	1.38	3.06	9.51	1.44	3.71			2.14	1.18	3.04	1.9							
October	2004								2.01	1.21	2.9	1.83							
November	2004								4.77	1.41	8.68	2.27							
December	2004	1.40	17.60	11.20	1.56	13.20			4.5	1.28	4.51	3.29							
January	2005																		
February	2005																		
March	2005	1.35	2.62	2.43	1.33	2.61			1.61	1.08	1.51	1.78		0.80	1.25	1.17	0.76	0.92	
April	2005	1.39	4.34	2.65	1.34	1.38			1.36	1.08	1.32	1.54							
May	2005	1.41	7.06	4.96	1.34	2.28			1.68	1.07	1.18	1.42							
June	2005																		
July	2005																		
August	2005																		
September	2005																		

October	2005																			
November	2005																			
December	2005																			
January	2006			3.30		4.30														
February	2006			2.70		3.10														
March	2006			4.00		1.80														
April	2006	1.32	8.06	4.83	1.49	3.40			2.48	1.3	3.07	4.06								
May	2006	1.30	9.54	4.29	1.47	3.47			2.4	1.18	2.77	2.96								
June	2006	1.32	16.80	3.85	1.41	3.33			2.55	1.13	2.85	5.45								
July	2006	1.20	7.78	2.81	1.30	5.53			3.11	1.11	3.4	2.59								
August	2006	1.18	3.99	4.27	1.32	6.83			3.19	1.24	4.17	2.8								
September	2006	1.14	2.32	3.26	1.24	5.65			2.54	1.24	3.9	2.44		0.91	0.93	1.00	0.70	0.80		
October	2006	2.37	2.04	2.76	1.31	3.71			2.44	1.3	3.77	2.33								
November	2006	1.48	10.40	3.74	1.15	2.26			0.6	1.25	4.98	1.84								
December	2006	1.16	2.93	4.30	1.23	5.05			1.47	1.2	2.47	1.52		1.03	2.03	2.06	1.07	1.75		
January	2007	1.09	11.40	3.59	1.28	3.65			1.2	1.05	1.95	1.33								
February	2007	1.17	7.13	4.93	1.38	3.01			1.31	1.09	1.73	1.34								
March	2007	1.27	5.35	4.33	1.39	2.92			1.29	1.08	1.5	1.35		1.01	2.65	2.11	1.11	2.10		
April	2007	1.34	3.98	4.25	1.30	3.36			1.23	1.13	1.51	1.36								
May	2007	1.41	7.77	6.14	1.34	3.38			1.2	1.17	1.43	1.31								
June	2007	1.43	21.30	5.20	1.31	3.76			4.796	1.09	1.57	1.86		1.01	3.15	2.40	0.98	2.66		
July	2007	1.36	5.07	4.64	1.18	5.54			8.36	1.34	4.97	5.72								
August	2007	2.43	2.77	4.18	1.34	5.15			7.08	1.65	5.92	6.47								
September	2007	3.19	1.98	3.67	1.44	4.14			5.16	1.78	6.01	5.48		1.12	1.51	1.23	1.02	1.29		
October	2007	2.46	2.07	3.15	1.46	2.93			3.65	1.97	6.05	3.95								
November	2007		6.56	3.49	1.54	2.68			2.86	2.1	6.11	3.01								
December	2007	1.81	1.23	4.08	1.76	2.61			2.41	2.23	5.74	2.52		1.18	1.38	1.22	1.06	1.34		
January	2008	1.55	6.56	4.55	1.88	2.04			1.88	1.77	3.91	1.9								
February	2008	1.63	10.70	5.24	1.89	2.62			1.87	1.7	3.49	1.92								
March	2008	1.66	10.50	5.09	1.82	3.51			1.72	1.54	2.67	1.81		1.04	8.12	2.21	1.34	2.57		
April	2008	1.82	22.40	5.95	2.07	4.82			1.78	1.58	2.49	1.9								
May	2008	1.75	20.20	9.97	1.76	6.85			2.08	1.45	3.28	3.48								
June	2008	1.80	15.90	5.95	1.60	6.85			3.29	1.19	2.17	2.32		0.78	1.91	1.87	0.93	1.42		
July	2008	2.06	16.40	5.80	1.58	5.99			5.8	1.33	4.9	4.27								
August	2008	1.96	13.50	6.05	1.73	6.05			5.37	1.64	7.84	5.7								
September	2008	3.00	11.60	5.91	1.75	5.45			5.42	1.79	9.04	5.48		1.16	1.47	1.24	1.17	1.54		
October	2008	3.03	6.39	5.89	1.89	4.69			4.69	1.84	6.92	5.12								
November	2008	2.34	5.77	7.23	2.25	5.03			4.81	2.11	6.98	4.95								
December	2008	1.71	1.46	5.54	2.32	4.90			4.66		5.81	3.79		1.47	4.53	2.55	1.34	2.40		
January	2009	1.61	0.87	4.13	2.20	3.43			3.2	1.96	4.94	3.32								
February	2009	1.69	2.84	3.13	2.09	2.26			2.19	1.79	3.45	2.63								
March	2009	1.72	4.89	2.60	1.83	1.68			3.35	1.5	3.1	2.73		1.17	1.71	1.73	1.20	1.57		
April	2009	1.86	11.90	2.62	1.83	1.57			3.75	1.49	3.05	3.06								
May	2009	1.93	12.20	2.55	1.76	1.80			1.99	1.39	2.05	2.3								
June	2009			2.80		2.10														
July	2009	2.04	7.57	3.28	1.78	2.68			3.53	1.46	3.29	3.17								
August	2009	2.13	5.85	2.55	1.72	2.71			3.52	1.47	3.64	2.89								
September	2009	2.97	4.05	3.40	1.79	2.89			4.11	1.62	4.24	3.63		1.03	1.57	1.28	1.13	1.39		
October	2009	2.46	2.68	3.61	1.87	2.66			3.87	1.68	4.51	3.67								

November	2009	2.13	1.92	3.85	1.88	2.52				3.35	1.7	4.22	3.37								
December	2009	2.03	10.10	5.25	2.06	3.43				8.79	2.59	15.2	10.5			1.13	4.70	0.06	1.29	2.57	
January	2010	1.96	2.04	3.62	2.15	3.38				2.86	1.85	4.71	3.77								
February	2010	1.96	2.20	3.59	2.08	3.07				3.04	1.75	3.51	3.28								
March	2010	1.95	8.61	2.74	2.00	2.18				2.78	1.68	2.39	2.52			0.87	4.09	2.39	1.44	2.34	
April	2010	1.90	4.46	3.12	1.94	2.21				2.41	1.59	2.59	2.73								
May	2010	1.80	13.10	3.85	1.80	2.33				1.87	1.62	2.23	2.28								
June	2010	1.74	13.40	5.86	1.93	4.32				3.91	1.79	2.32	2.57			0.79	2.01	3.17	0.95	1.72	
July	2010	2.31	21.10	4.48	2.04	4.58				5.22	1.87	3.12	4.19								
August	2010	1.88	9.20	4.15	1.88	4.47				5.51	1.79	5.69	4.53								
September	2010	2.10	15.60	6.10	1.94	4.61				5.7	2.12	7.05	5.67			0.81	1.23	1.01	0.81	1.16	
October	2010	1.94	21.40	6.90	2.06	7.03				5.16	2.36	7.92	5.39								
November	2010	1.71	8.55	6.59	2.12	7.28				4.22	2.26	7.07	4.38								
December	2010	1.58	7.37	5.56	2.22	6.63				3.61	2.11	5.44	3.7			1.22	4.27	2.85	1.13	2.30	
January	2011	1.62	9.82	4.85	2.17	5.27				3.08	2.02	4.07	3.24								
February	2011	1.78	8.70	3.94	1.91	4.09				2.71	1.9	2.88	2.81								
March	2011																				
April	2011																				
May	2011																				
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July	2013																		
August	2013																		
September	2013																		
October	2013						2.92						3.85						3.05
November	2013																		
December	2013	1.51		3.93		3.58	3.67				2.92	3.08	3.06	1.07		2.84		2.61	2.54
January	2014						3.79						2.80						2.02
February	2014						3.57						2.74						2.46
March	2014	1.41		3.30		3.59	3.72				2.55	2.48	2.9	0.75		3.66		1.22	1.17
April	2014						3.6						2.98						1.43
May	2014						2.7						2.58						1.05
June	2014	0.37		4.90		5.03	2.65				2.29	2.49	2.95	0.89		1.12		1.22	1.23
July	2014						2.69						3.08						1.16
August	2014						2.63						2.71						1.12
September	2014	1.04		2.38		3.02	2.15				3.54	2.96	2.73	0.93		1.08		1.21	1.22
October	2014						3.62						2.83						1.34
November	2014						5.22						2.76						5.57
December	2014	1.30		4.94		6.33	4.63				3.38	2.34	2.35	1.11		4.92		4.50	4.77
January	2015						4.44						2.42						3.91
February	2015						4.61						2.6						2.72
March	2015	1.60		3.60		5.35	2.78				2.11	2.16	2.53	0.85		2.76		2.80	2.82
April	2015						3.03						2.42						2.74
May	2015						2.71						2.56						0.99
June	2015	0.81		4.48		7.27	3.61				1.72	2.1	2.24	0.57		1.40		1.47	1.46
July	2015						3.42						2.8						1.31
August	2015						3.26						3.11						1.07
September	2015	1.53		2.07		4.39	2.62				2.63	3.25	3.05	0.92		1.10		1.45	1.46
October	2015						2.59						3.23						1.38
November	2015						3.13						3.36						3.29
December	2015	1.82		3.67		4.60					3.56	3.45		0.97		3.10		2.90	
January	2016						3.49						3.13						2.37
February	2016						3.22						3.01						2.02
March	2016	1.76		3.58		3.32	3.04				2.79	2.83	3.45	0.66		2.55		2.36	2.33
April	2016						2.84						3.44						3.64
May	2016						3.31						3.45						3.22
June	2016	0.66		4.99		6.40	4.03				2.52	2.8	3.45	0.74		2.05		1.04	1.03
July	2016						3.66						3.52						0.77
August	2016						3.65						3.6						0.81
September	2016	1.65		3.00		5.80	2.94				2.57	3.38	3.46	0.83		0.90		0.76	0.79
October	2016						2.81						3.55						0.91
November	2016						2.37						3.61						3.22
December	2016	1.39		4.51		4.62	2.42				3.2	3.46	3.25	0.99		2.97		2.63	2.65
January	2017						2.76						3.13						1.96
February	2017						2.89						3						1.97
March	2017	1.39		3.21		3.86	2.73				2.57	2.7	2.9	0.84		2.61		2.64	2.6
April	2017						2.45						2.85						3.25
May	2017																		
June	2017																		

Monitoring Wells Summary
Total Kjeldahl Nitrogen Concentration (mg/L)
2002 to 2016

Month	Year	1A	2A	3A	4A	5A	6A	1B	2B	3B	4B	5B	6B	1C	2C	3C	4C	5C	6C
January	2002																		
February	2002																		
March	2002																		
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July	2006																			
August	2006	ND																		
September	2006	ND													ND					
October	2006																			
November	2006																			
December	2006																			
January	2007	ND																		
February	2007																			
March	2007																			
April	2007																			
May	2007																			
June	2007	ND													ND					
July	2007																			
August	2007	ND																		
September	2007																			
October	2007	ND																		
November	2007																			
December	2007	ND													ND					
January	2008	0.6																		
February	2008	ND																		
March	2008	ND													ND					
April	2008																			
May	2008																			
June	2008	ND													ND					
July	2008	ND																		
August	2008	ND																		
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November	2008																			
December	2008																			
January	2009	ND																		
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July	2009	ND																		
August	2009	ND																		
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November	2009	ND																		
December	2009	ND													ND					
January	2010	ND																		
February	2010	ND																		
March	2010	ND													ND					
April	2010	ND																		
May	2010	ND																		
June	2010	ND													ND					
July	2010	ND																		
August	2010	ND																		
September	2010	ND													ND					
October	2010	ND																		
November	2010	ND																		
December	2010	ND													ND					
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June	2013																		
July	2013																		
August	2013																		
September	2013																		
October	2013						ND						ND						ND
November	2013																		
December	2013	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
January	2014						ND						ND						ND
February	2014						ND						ND						ND
March	2014	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
April	2014						ND						ND						ND
May	2014						ND						ND						ND
June	2014	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
July	2014						ND						ND						ND
August	2014						ND						ND						ND
September	2014	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
October	2014						ND						ND						ND
November	2014						ND						ND						ND
December	2014	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
January	2015						ND						ND						ND
February	2015						ND						ND						ND
March	2015	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
April	2015						ND						ND						ND
May	2015						ND						ND						ND
June	2015	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
July	2015						ND						ND						ND
August	2015						ND						ND						ND
September	2015	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
October	2015						ND						ND						ND
November	2015						ND						ND						ND
December	2015	ND		ND		ND					ND	ND		ND		ND		ND	
January	2016						ND						ND						ND
February	2016						ND						ND						ND
March	2016	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
April	2016						ND						ND						ND
May	2016						ND						ND						ND
June	2016	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
July	2016						ND						ND						ND
August	2016						ND						ND						ND
September	2016	0.5		ND		ND	ND				0.5	0.6	24.1	0.5		ND		ND	ND
October	2016						ND						ND						ND
November	2016						ND						ND						ND
December	2016	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
January	2017						ND						ND						ND
February	2017						ND						ND						ND
March	2017	ND		ND		ND	ND				ND	ND	ND	ND		ND		ND	ND
April	2017						ND						ND						ND
May	2017																		
June	2017																		

Monitoring Wells Summary
Total Nitrogen Concentration (mg/L)
2002 to 2016

Month	Year	1A	2A	3A	4A	5A	6A	1B	2B	3B	4B	5B	6B	1C	2C	3C	4C	5C	6C
January	2002							1.1	1.8	1.1	1.8	1.9							
February	2002										.								
March	2002							1.1	2.7	1.0	1.5	2.2							
April	2002																		
May	2002																		
June	2002							1.1	9.0	0.9	1.9	8.5							
July	2002																		
August	2002							1.1	1.5	1.0	1.7	2.8							
September	2002							1.2	1.6	1.0	1.7	2.4							
October	2002							1.2	1.5	1.0	1.8	2.1							
November	2002							1.1	10.6	1.2	6.3	4.2							
December	2002							1.2	2.2	1.7	6.8	4.2							
January	2003							1.3	3.9	1.0	2.1	2.4		0.9	1.1	0.9	0.9	1.0	
February	2003							1.3	2.6	1.0	2.7	3.6							
March	2003		1.2	1.8	1.2	0.5		1.3	4.5	1.0	2.7	3.5		0.8	1.0	0.9	0.9	1.1	
April	2003								3.4	1.0	3.3	5.1							
May	2003								1.9	0.9	1.9	4.9							
June	2003	1.7	3.4	2.1	1.2	0.6			1.7	1.0	1.2	2.4		0.8	1.1	0.8	0.9	0.9	
July	2003								1.8	1.0	1.6	1.8							
August	2003								1.8	1.1	2.9	1.6							
September	2003	1.3	1.7	1.4	1.3	0.6			1.7	1.1	2.3	1.4		0.8	0.9	0.8	0.8	0.9	
October	2003								1.5	1.1	2.4	1.3							
November	2003								5.6	1.6	6.1	4.3							
December	2003	1.2	4.5	1.6	1.3	1.3			3.3	1.8	5.5	4.8		0.8	1.0	0.7	0.8	0.9	
January	2004								1.3	1.1	1.8	1.6							
February	2004								2.6	1.0	4.0	3.6							
March	2004	1.4	1.1	3.4	1.3	1.2			1.8	1.0	2.7	3.1							
April	2004								6.0	1.0	2.7	3.8							
May	2004								3.0	1.2	5.7	8.1							
June	2004	1.3	17.8	3.7	1.4	1.6			2.1	1.1	2.9	3.9							
July	2004								2.6	0.9	3.4	2.6							
August	2004								2.3	1.2	3.8	2.2							
September	2004	1.4	4.1	9.5	1.4	3.7			2.1	1.2	3.0	1.9							
October	2004								2.0	1.2	2.9	1.8							
November	2004								4.8	1.4	8.7	2.3							
December	2004	1.4	20.0	11.2	1.6	13.2			4.5	1.3	4.5	3.3							
January	2005																		
February	2005																		
March	2005	1.4	3.2	2.4	1.3	2.6			1.6	1.1	1.5	1.8		0.8	1.3	1.2	0.8	0.9	
April	2005	1.4	4.3	2.7	1.3	1.4			1.4	1.1	1.3	1.5							
May	2005	1.4	7.1	5.0	1.3	2.3			1.7	1.1	1.2	1.4							
June	2005																		
July	2005																		

August	2005																		
September	2005																		
October	2005																		
November	2005																		
December	2005																		
January	2006			3.3		4.3													
February	2006			2.7		3.1													
March	2006			4.0		1.8													
April	2006	1.3	8.1	4.8	1.5	3.4			2.5	1.3	3.1	4.1							
May	2006	1.3	9.5	4.3	1.5	3.5			2.4	1.2	2.8	3.0							
June	2006	1.3	17.0	3.9	1.4	3.3			2.6	1.1	2.9	5.5							
July	2006	1.2	8.1	2.8	1.3	5.5			3.1	1.1	3.4	2.6							
August	2006	1.2	4.6	4.3	1.3	6.8			3.2	1.2	4.2	2.8							
September	2006	1.1	3.2	3.3	1.2	5.7			2.5	1.2	3.9	2.4		0.9	0.9	1.0	0.7	0.8	
October	2006	2.4	3.3	2.8	1.3	3.7			2.4	1.3	3.8	2.3							
November	2006	1.5	10.9	3.7	1.2	2.3			0.6	1.3	5.0	1.8							
December	2006	1.2	3.4	4.3	1.2	5.1			1.5	1.2	2.5	1.5		1.0	2.0	2.1	1.1	1.8	
January	2007	1.1	11.9	3.6	1.3	3.7			1.2	1.1	2.0	1.3							
February	2007	1.2	7.3	4.9	1.4	3.0			1.3	1.1	1.7	1.3							
March	2007	1.3	5.4	4.3	1.4	2.9			1.3	1.1	1.5	1.4		1.0	2.7	2.1	1.1	2.1	
April	2007	1.3	4.0	4.3	1.3	3.4			1.2	1.1	1.5	1.4							
May	2007	1.4	7.8	6.1	1.3	3.4			1.2	1.2	1.4	1.3							
June	2007	1.4	21.3	5.2	1.3	3.8			4.8	1.1	1.6	1.9		1.0	3.2	2.4	1.0	2.7	
July	2007	1.4	5.6	4.6	1.2	5.5			8.4	1.3	5.0	5.7							
August	2007	2.4	3.6	4.2	1.3	5.2			7.1	1.7	5.9	6.5							
September	2007	3.2	3.1	3.7	1.4	4.1			5.2	1.8	6.0	5.5		1.1	1.5	1.2	1.0	1.3	
October	2007	2.5	3.6	3.2	1.5	2.9			3.7	2.0	6.1	4.0							
November	2007		8.3	3.5	1.5	2.7			2.9	2.1	6.1	3.0							
December	2007	1.8	2.9	4.1	1.8	2.6			2.4	2.2	5.7	2.5		1.2	1.4	1.2	1.1	1.3	
January	2008	1.6	6.8	4.6	1.9	2.0			1.9	1.8	3.9	1.9							
February	2008	1.6	10.7	5.2	1.9	2.6			1.9	1.7	3.5	1.9							
March	2008	1.7	10.5	5.1	1.8	3.5			1.7	1.5	2.7	1.8		1.0	8.1	2.2	1.3	2.6	
April	2008	1.8	22.9	6.0	2.1	4.8			1.8	1.6	2.5	1.9							
May	2008	1.8	20.4	10.0	1.8	6.9			2.1	1.5	3.3	3.5							
June	2008	1.8	16.3	6.0	1.6	6.9			3.3	1.2	2.2	2.3		0.8	1.9	1.9	0.9	1.4	
July	2008	2.1	17.1	5.8	1.6	6.0			5.8	1.3	4.9	4.3							
August	2008	2.0	14.3	6.1	1.7	6.1			5.4	1.6	7.8	5.7							
September	2008	3.0	12.4	5.9	1.8	5.5			5.4	1.8	9.0	5.5		1.2	1.5	1.2	1.2	1.5	
October	2008	3.0	7.4	5.9	1.9	4.7			4.7	1.8	6.9	5.1							
November	2008	2.3	7.0	7.2	2.3	5.0			4.8	2.1	7.0	5.0							
December	2008	1.7	3.0	5.5	2.3	4.9			4.7		5.8	3.8		1.5	4.5	2.6	1.3	2.4	
January	2009	1.6	2.6	4.1	2.2	3.4			3.2	2.0	4.9	3.3							
February	2009	1.7	4.7	3.1	2.1	2.3			2.2	1.8	3.5	2.6							
March	2009	1.7	6.6	2.6	1.8	1.7			3.4	1.5	3.1	2.7		1.2	1.7	1.7	1.2	1.6	
April	2009	1.9	13.7	2.6	1.8	1.6			3.8	1.5	3.1	3.1							
May	2009	1.9	13.6	2.6	1.8	1.8			2.0	1.4	2.1	2.3							
June	2009			2.8		2.1													

July	2009	2.0	9.0	3.3	1.8	2.7			3.5	1.5	3.3	3.2								
August	2009	2.1	7.3	2.6	1.7	2.7			3.5	1.5	3.6	2.9								
September	2009	3.0	5.5	3.4	1.8	2.9			4.1	1.6	4.2	3.6		1.0	1.6	1.3	1.1	1.4	
October	2009	2.5	4.4	3.6	1.9	2.7			3.9	1.7	4.5	3.7							
November	2009	2.1	3.6	3.9	1.9	2.5			3.4	1.7	4.2	3.4							
December	2009	2.0	10.5	5.3	2.1	3.4			8.8	2.6	15.2	10.5		1.1	4.7	0.1	1.3	2.6	
January	2010	2.0	3.0	3.6	2.2	3.4			2.9	1.9	4.7	3.8							
February	2010	2.0	3.3	3.6	2.1	3.1			3.0	1.8	3.5	3.3							
March	2010	2.0	8.8	2.7	2.0	2.2			2.8	1.7	2.4	2.5		0.9	4.1	2.4	1.4	2.3	
April	2010	1.9	4.6	3.1	1.9	2.2			2.4	1.6	2.6	2.7							
May	2010	1.8	13.2	3.9	1.8	2.3			1.9	1.6	2.2	2.3							
June	2010	1.7	13.5	5.9	1.9	4.3			3.9	1.8	2.3	2.6		0.8	2.0	3.2	1.0	1.7	
July	2010	2.3	21.4	4.5	2.0	4.6			5.2	1.9	3.1	4.2							
August	2010	1.9	9.6	4.2	1.9	4.5			5.5	1.8	5.7	4.5							
September	2010	2.1	15.7	6.1	1.9	4.6			5.7	2.1	7.1	5.7		0.8	1.2	1.0	0.8	1.2	
October	2010	1.9	21.7	6.9	2.1	7.0			5.2	2.4	7.9	5.4							
November	2010	1.7	9.2	6.6	2.1	7.3			4.2	2.3	7.1	4.4							
December	2010	1.6	7.6	5.7	2.2	6.6			3.6	2.1	5.4	3.7		1.2	4.3	2.9	1.1	2.3	
January	2011	1.6	9.9	4.9	2.2	5.3			3.1	2.0	4.1	3.2							
February	2011	1.8	9.5	3.9	1.9	4.1			2.7	1.9	2.9	2.8							
March	2011																		
April	2011																		
May	2011																		
June	2011																		
July	2011																		
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June	2013																		
July	2013																		
August	2013																		
September	2013																		
October	2013																		
November	2013																		
December	2013	1.5		3.9		3.6	3.7				2.9	3.1	3.1	1.1		2.8		2.6	2.5
January	2014						3.8						2.8						2
February	2014						3.6						2.7						2.5
March	2014	1.4		3.0		3.6	3.7				2.6	2.5	2.9	0.8		3.7		1.2	1.2
April	2014						3.6						3						1.4
May	2014						2.7						2.6						1
June	2014	ND		4.9		5.0	2.6				2.3	2.5	3	0.9		1.1		1.2	1.2
July	2014						2.7						3.1						1.2
August	2014						2.6						2.7						1.1
September	2014	1.0		2.4		3.0	2.2				3.5	3	2.7	0.9		1.1		1.2	1.2
October	2014						3.6						2.8						1.3
November	2014						5.2						2.8						5.6
December	2014	1.3		4.9		6.3	4.6				3.4	2.3	2.4	1.1		4.9		4.5	4.8
January	2015						4.4						2.4						3.9
February	2015						4.6						2.6						2.7
March	2015																		
April	2015						3						2.4						2.7
May	2015						2.7						2.6						1
June	2015	0.8		4.5		7.3	3.6				1.7	2.1	2.2	0.6		1.4		1.5	1.5
July	2015						3.4						2.8						1.3
August	2015						3.3						3.1						1.1
September	2015																		
October	2015						2.6						3.2						1.4
November	2015						3.1						3.4						3.3
December	2015	1.8		3.7		4.6					3.6	3.4		1.0		3.1		2.9	
January	2016						3.5						3.1						2.4
February	2016						3.2						3						2
March	2016																		
April	2016																		
May	2016																		
June	2016																		
July	2016						3.7						3.5						0.8
August	2016						3.6						3.6						0.8
September	2016	2.2		3.0		5.8	2.9				3.1	4	27.6	1.3		0.9		0.8	0.8
October	2016						2.8						3.6						0.9
November	2016						2.4						3.6						3.2
December	2016	1.4		4.5		4.6	2.4				3.2	3.5	3.2	1.0		3.0		2.6	2.6
January	2017						2.8						3.1						2
February	2017						2.9						3						2
March	2017	1.4		3.2		3.9	2.7				2.6	2.7	2.9	0.8		2.6		2.6	2.6
April	2017						2.6						2.8						3.3

EXISTING PIPELINE CAPACITY CALCULATIONS

Hydraulic Analysis Report

Project Data

Project Title: BWTP Piping

Designer:

Project Date: Thursday, April 20, 2017

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Distribution 21-inch

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.7500 ft

Longitudinal Slope: 0.0010 ft/ft

Manning's n: 0.0110

Depth: 1.4875 ft

Result Parameters

Flow: 6.1019 cfs

Area of Flow: 2.1790 ft^2

Wetted Perimeter: 4.1058 ft

Hydraulic Radius: 0.5307 ft

Average Velocity: 2.8003 ft/s

Top Width: 1.2497 ft

Froude Number: 0.3737

Critical Depth: 0.9100 ft

Critical Velocity: 4.8277 ft/s

Critical Slope: 0.0037 ft/ft

Critical Top Width: 1.75 ft

Calculated Max Shear Stress: 0.0928 lb/ft^2

Calculated Avg Shear Stress: 0.0331 lb/ft^2

Channel Analysis: Distribution 18-inch

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.5000 ft

Longitudinal Slope: 0.0020 ft/ft

Manning's n: 0.0110

Depth: 1.2750 ft

Result Parameters

Flow: 5.7208 cfs

Area of Flow: 1.6009 ft^2

Wetted Perimeter: 3.5193 ft

Hydraulic Radius: 0.4549 ft

Average Velocity: 3.5734 ft/s

Top Width: 1.0712 ft

Froude Number: 0.5151

Critical Depth: 0.9229 ft

Critical Velocity: 5.0159 ft/s

Critical Slope: 0.0044 ft/ft

Critical Top Width: 1.46 ft

Calculated Max Shear Stress: 0.1591 lb/ft^2

Calculated Avg Shear Stress: 0.0568 lb/ft^2

Channel Analysis: Distribution 15-inch

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.2500 ft

Longitudinal Slope: 0.0020 ft/ft

Manning's n: 0.0110

Depth: 1.0625 ft

Result Parameters

Flow: 3.5181 cfs

Area of Flow: 1.1118 ft^2

Wetted Perimeter: 2.9327 ft

Hydraulic Radius: 0.3791 ft

Average Velocity: 3.1644 ft/s

Top Width: 0.8927 ft

Froude Number: 0.4997

Critical Depth: 0.7568 ft

Critical Velocity: 4.5269 ft/s

Critical Slope: 0.0046 ft/ft

Critical Top Width: 1.22 ft

Calculated Max Shear Stress: 0.1326 lb/ft^2

Calculated Avg Shear Stress: 0.0473 lb/ft^2

Channel Analysis: Bypass 21-inch

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.7500 ft

Longitudinal Slope: 0.0010 ft/ft

Manning's n: 0.0110

Depth: 1.4875 ft

Result Parameters

Flow: 6.1019 cfs

Area of Flow: 2.1790 ft^2

Wetted Perimeter: 4.1058 ft

Hydraulic Radius: 0.5307 ft

Average Velocity: 2.8003 ft/s

Top Width: 1.2497 ft

Froude Number: 0.3737

Critical Depth: 0.9100 ft

Critical Velocity: 4.8277 ft/s

Critical Slope: 0.0037 ft/ft

Critical Top Width: 1.75 ft

Calculated Max Shear Stress: 0.0928 lb/ft^2

Calculated Avg Shear Stress: 0.0331 lb/ft^2

Channel Analysis: Transfer Line C

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.3333 ft

Longitudinal Slope: 0.0097 ft/ft

Manning's n: 0.0110

Depth: 1.1333 ft

Result Parameters

Flow: 9.2026 cfs

Area of Flow: 1.2649 ft^2

Wetted Perimeter: 3.1282 ft

Hydraulic Radius: 0.4044 ft

Average Velocity: 7.2754 ft/s

Top Width: 0.9522 ft

Froude Number: 1.1124

Critical Depth: 1.1803 ft

Critical Velocity: 7.0390 ft/s

Critical Slope: 0.0092 ft/ft

Critical Top Width: 0.85 ft

Calculated Max Shear Stress: 0.6860 lb/ft^2

Calculated Avg Shear Stress: 0.2447 lb/ft^2

BELGRADE SEWER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Designed by: NMR
Checked by: CEVJ
Date: 4/12/2017

Wastewater Treatment Plant
Existing System
Transfer Pump Equation

BLUE TEXT = USER INPUTS
RED TEXT = CALCULATION RESULTS
GREEN TEXT = ENERGY EQUATION TERM

Project Specific Design Criteria:

Q =	**1330**	gpm	(Original pump design capacity)
Q =	**2.9632**	cfs	(1 gal = 0.13368 CF)
v =	**0.0000121**	ft2/sec	(assume water 60°F)

Assumptions:

Darcy-Weisbach friction losses

Equations:

Energy:

$$\frac{v_1^2}{2g} + z_1 + \frac{P_1}{\gamma} + h_P = \frac{v_2^2}{2g} + z_2 + \frac{P_2}{\gamma} + h_T + h_m + h_f$$

Reynold's Number:

$$Re = \frac{4Q}{\pi D \upsilon}$$

Minor Head Loss:

$$h_m = k\frac{v^2}{2g} = k\frac{Q^2}{2gA^2}$$

Darcy Weisbach Friction Head Loss:

$$h_f = f\frac{Lv^2}{D2g} = f\frac{LQ^2}{D2gA_p^2}$$

Swamee-Jain Friction Factor:

$$f = \frac{0.25}{\left(\log\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{Re^{0.9}}\right)\right)^2}$$

Appropriate if:
10^-6 < ε/D < 10^-2
5000 < Re < 10^8

Hazen-Williams Friction Head Loss:

$$h_f = 3.02LD^{-1.167}\left(\frac{v}{C_h}\right)^{1.85} = 3.02LD^{-1.167}\left(\frac{Q}{C_hA}\right)^{1.85}$$

System Properties:

Lagoon #2	Pipe A			Pipe B			Pipe C			Lagoon #3
open to atmosphere	16" PVC			12" SDR18 C900 PVC			10" SDR18 C900 PVC			open to atmosphere
4410.9	ε =	**0.0000625**	ft	ε =	**0.000416667**	ft	ε =	**0.0001**	ft	**4415.25**
	ID =	**16**	in	ID =	**12**	in	ID =	**9.79**	in	
	D =	**1.333**	ft	D =	**1.000**	ft	D =	**0.816**	ft	
	A =	**1.396**	ft2	A =	**0.785**	ft2	A =	**0.523**	ft2	
	vp =	**2.122**	ft/sec	vp =	**3.773**	ft/sec	vp =	**5.669**	ft/sec	
	Re =	**233,858**		Re =	**311,811**		Re =	**382,200**		
	ε/D =	**0.00005**		ε/D =	**0.00042**		ε/D =	**0.000123**		
	L =	**1,273**	ft	L =	**1,256**	ft	L =	**-**	ft	
	f =	**0.01553**	(S-J eqn)	f =	**0.01778**	(S-J eqn)	f =	**0.01518**	(S-J eqn)	
	C_h =	**150**	(Hazen-Williams)	C_h =	**135**	(Hazen-Williams)	C_h =	**140**	(Hazen-Williams)	
	Σk =	**20.000**	(fittings)	Σk =	**20.000**	(fittings)	Σk =	**-**	(fittings)	

Energy Equation:

Each term is calculated separately and then used to find the pump head.

Velocity Head 1

v1 =	0	ft/sec	(negligible)
g =	32.2	ft/sec2	(gravity)
	0	ft	

Velocity Head 2

v2 =	0	ft/sec	(negligible)
g =	32.2	ft/sec2	(gravity)
	0	ft	

Elevation Head 1

z1 =	4410.9	ft

Elevation Head 2

z2 =	4415.25	ft

Pressure Head 1

P1 =	0	LB/ft2	(atmosphere)
γ =	62.4	LB/ft3	
	0	ft	

Pressure Head 2

P2 =	0		(atmosphere)
γ =	62.4	LB/ft2	
	0	ft	

Pump Head

hp =	16.14	ft	RESULT

Turbine Head

hT =	0	ft	(N/A)

Friction Head Loss

Darcy-Weisbach (Used in Energy Equation):				Hazen-Williams (Check only):		
g =	32.2	ft/sec2	(gravity)			
Pipe A				Pipe A		
hf =	1.04	ft		hf =	1.042	ft
Pipe B				Pipe B		
hf =	4.94	ft		hf =	5.067	ft
Pipe C				Pipe C		
hf =	0.00	ft		hf =	-	ft

Minor Head Loss

g =	32.2	ft/sec2	(gravity)
Pipe A			
hm =	1.40	ft	
Pipe B			
hm =	4.42	ft	
Pipe C			
hm =	0.00	ft	

BELGRADE SEWER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Designed by: NMR
Checked by: CEVJ
Date: 4/12/2017

Wastewater Treatment Plant
Existing System
Transfer Line B Sizing

BLUE TEXT = USER INPUTS
RED TEXT = CALCULATION RESULTS
GREEN TEXT = ENERGY EQUATION TERM

Project Specific Design Criteria:

Q =	**1090.3** gpm	(Original pump design capacity)	**1,570,000**	**gpd**
Q =	**2.4291** cfs	(1 gal = 0.13368 CF)		
v =	**0.0000121** ft2/sec	(assume water 60°F)		

Assumptions:

Darcy-Weisbach friction losses

Equations:

Energy:

$$\frac{v_1^2}{2g} + z_1 + \frac{P_1}{\gamma} + h_p = \frac{v_2^2}{2g} + z_2 + \frac{P_2}{\gamma} + h_T + h_m + h_f$$

Reynold's Number:

$$Re = \frac{4Q}{\pi D \upsilon}$$

Minor Head Loss:

$$h_m = k\frac{v^2}{2g} = k\frac{Q^2}{2gA^2}$$

Darcy Weisbach Friction Head Loss:

$$h_f = f\frac{Lv^2}{D2g} = f\frac{LQ^2}{D2gA_p^2}$$

Swamee-Jain Friction Factor:

$$f = \frac{0.25}{\left(\log\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{Re^{0.9}}\right)\right)^2}$$

Appropriate if:
10^-6 < ε/D < 10^-2
5000 < Re < 10^8

Hazen-Williams Friction Head Loss:

$$h_f = 3.02LD^{-1.167}\left(\frac{v}{C_h}\right)^{1.85} = 3.02LD^{-1.167}\left(\frac{Q}{C_h A}\right)^{1.85}$$

System Properties:

Lagoon #2	Pipe A			Pipe B			Pipe C			Lagoon #3
open to atmosphere	16" PVC			12" SDR18 C900 PVC			10" SDR18 C900 PVC			open to atmosphere
4410.9	ε =	**0.000416667**	ft	ε =	**0.000416667**	ft	ε =	**0.0001**	ft	**4410.35745**
	ID =	**16**	in	ID =	**11.65**	in	ID =	**9.79**	in	
	D =	**1.333**	ft	D =	**0.971**	ft	D =	**0.816**	ft	
	A =	**1.396**	ft2	A =	**0.740**	ft2	A =	**0.523**	ft2	
	vp =	**1.740**	ft/sec	vp =	**3.282**	ft/sec	vp =	**4.647**	ft/sec	
	Re =	**191,707**		Re =	**263,289**		Re =	**313,311**		
	ε/D =	**0.00031**		ε/D =	**0.00043**		ε/D =	**0.000123**		
	L =	**486**	ft	L =	**-**	ft	L =	**-**	ft	
	f =	**0.01795**	(S-J eqn)	f =	**0.01810**	(S-J eqn)	f =	**0.01556**	(S-J eqn)	
	C_h =	**135**	(Hazen-Williams)	C_h =	**135**	(Hazen-Williams)	C_h =	**140**	(Hazen-Williams)	
	Σk =	**5.000**	(fittings)	Σk =	**-**	(fittings)	Σk =	**-**	(fittings)	

Energy Equation:

Each term is calculated separately and then used to find the pump head.

Velocity Head 1			
v1 =	0	ft/sec	(negligible)
g =	32.2	ft/sec2	(gravity)
	0	ft	
Elevation Head 1			
z1 =	4410.9	ft	
Pressure Head 1			
P1 =	0	LB/ft2	(atmosphere)
γ =	62.4	LB/ft3	
	0	ft	
Pump Head			
hp =	-	ft	RESULT

Velocity Head 2			
v2 =	0	ft/sec	(negligible)
g =	32.2	ft/sec2	(gravity)
	0	ft	
Elevation Head 2			
z2 =	4410.357	ft	
Pressure Head 2			
P2 =	0		(atmosphere)
γ =	62.4	LB/ft2	
	0	ft	
Turbine Head			
hT =	0	ft	(N/A)

Friction Head Loss

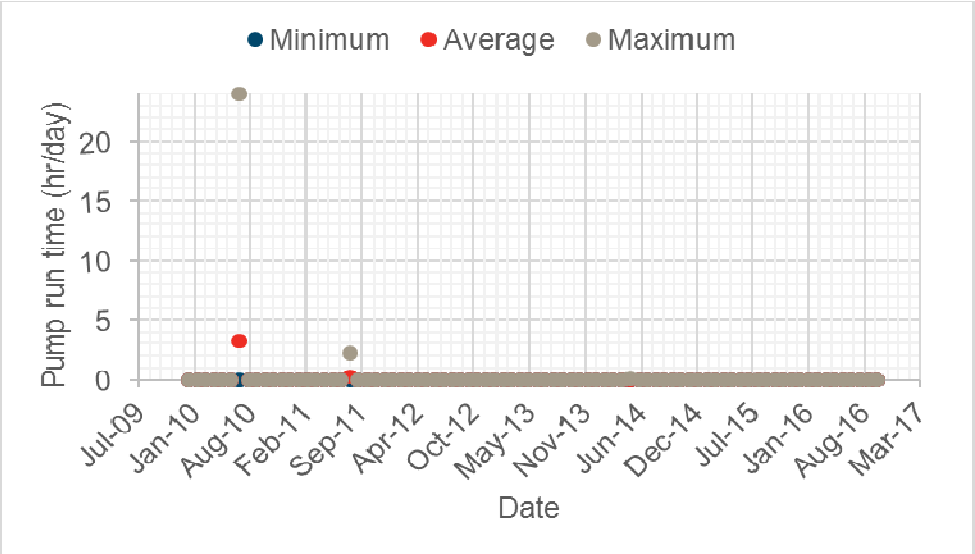
Darcy-Weisbach (Used in Energy Equation):			Hazen-Williams (Check only):		
g =	32.2	ft/sec2 (gravity)			
Pipe A			Pipe A		
hf =	0.31	ft	hf =	0.335	ft
Pipe B			Pipe B		
hf =	0.00	ft	hf =	-	ft
Pipe C			Pipe C		
hf =	0.00	ft	hf =	-	ft

Minor Head Loss

g =	32.2	ft/sec2	(gravity)
Pipe A			
hm =	0.23	ft	
Pipe B			
hm =	0.00	ft	
Pipe C			
hm =	0.00	ft	

EXISTING PUMP RUN TIME ANALYSIS

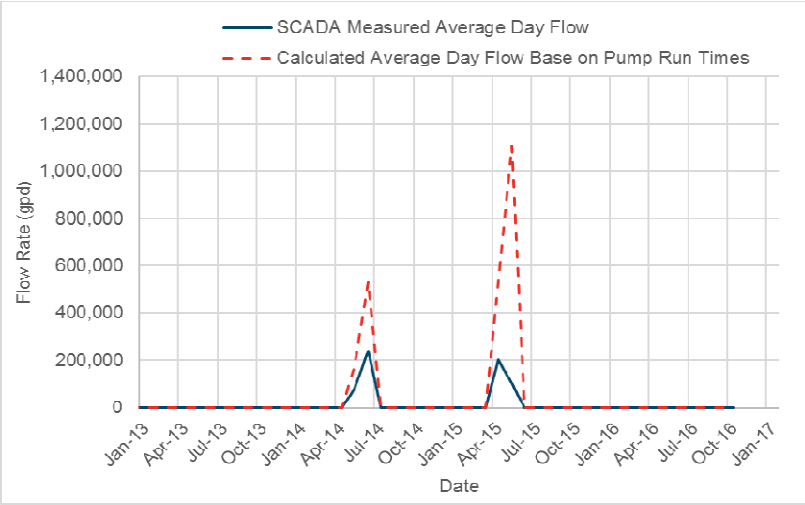
Transfer Pump Run Times

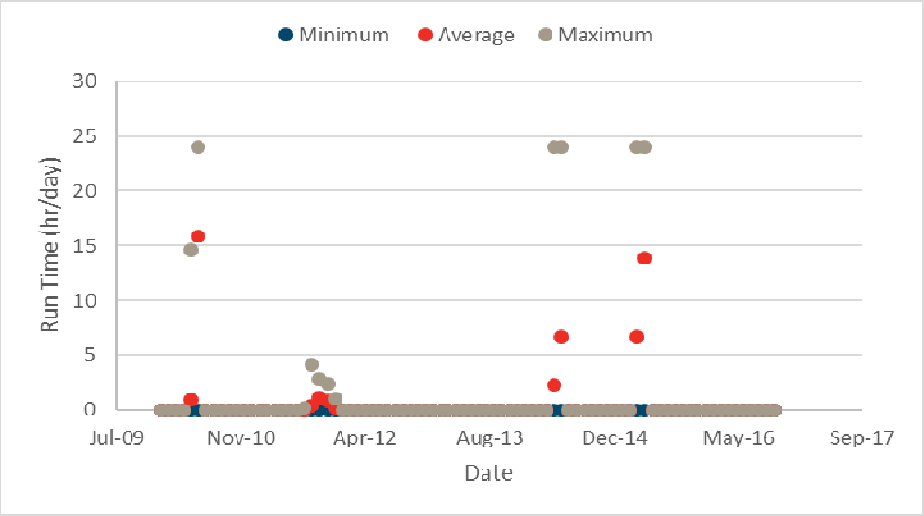


Date	Min	Average	Max	Date	Min	Average	Max
Jan-10	0	0	0	Jun-13	0	0	0
Feb-10	0	0	0	Jul-13	0	0	0
Mar-10	0	0	0	Aug-13	0	0	0
Apr-10	0	0	0	Sep-13	0	0	0
May-10	0	0	0	Oct-13	0	0	0
Jun-10	0	0	0	Nov-13	0	0	0
Jul-10	0	3.219355	24	Dec-13	0	0	0
Aug-10	0	0	0	Jan-14	0	0	0
Sep-10	0	0	0	Feb-14	0	0	0
Oct-10	0	0	0	Mar-14	0	0	0
Nov-10	0	0	0	Apr-14	0	0	0
Dec-10	0	0	0	May-14	0	0.002258	0.07
Jan-11	0	0	0	Jun-14	0	0	0
Feb-11	0	0	0	Jul-14	0	0	0
Mar-11	0	0	0	Aug-14	0	0	0
Apr-11	0	0	0	Sep-14	0	0	0
May-11	0	0	0	Oct-14	0	0	0
Jun-11	0	0	0	Nov-14	0	0	0
Jul-11	0	0	0	Dec-14	0	0	0
Aug-11	0	0.302903	2.22	Jan-15	0	0	0
Sep-11	0	0	0	Feb-15	0	0	0
Oct-11	0	0	0	Mar-15	0	0	0
Nov-11	0	0	0	Apr-15	0	0	0
Dec-11	0	0	0	May-15	0	0	0
Jan-12	0	0	0	Jun-15	0	0	0
Feb-12	0	0	0	Jul-15	0	0	0
Mar-12	0	0	0	Aug-15	0	0	0

Apr-12	0	0	0	Sep-15	0	0	0
May-12	0	0	0	Oct-15	0	0	0
Jun-12	0	0	0	Nov-15	0	0	0
Jul-12	0	0	0	Dec-15	0	0	0
Aug-12	0	0	0	Jan-16	0	0	0
Sep-12	0	0	0	Feb-16	0	0	0
Oct-12	0	0	0	Mar-16	0	0	0
Nov-12	0	0	0	Apr-16	0	0	0
Dec-12	0	0	0	May-16	0	0	0
Jan-13	0	0	0	Jun-16	0	0	0
Feb-13	0	0	0	Jul-16	0	0	0
Mar-13	0	0	0	Aug-16	0	0	0
Apr-13	0	0	0	Sep-16	0	0	0
May-13	0	0	0	Oct-16	0	0	0

Recycle Pump Run Times



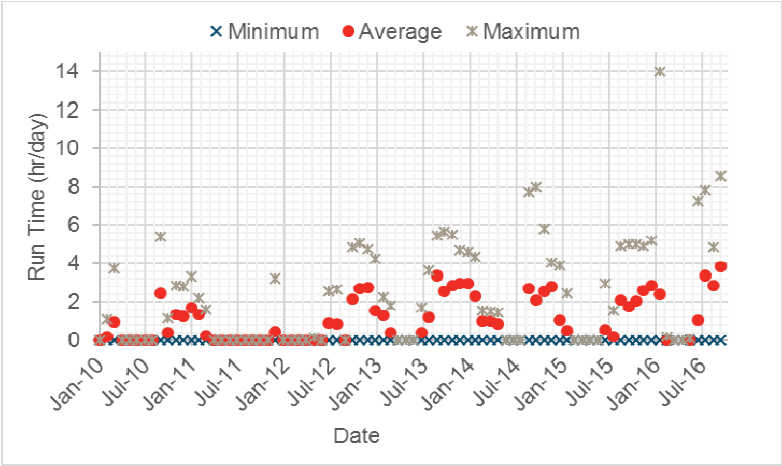


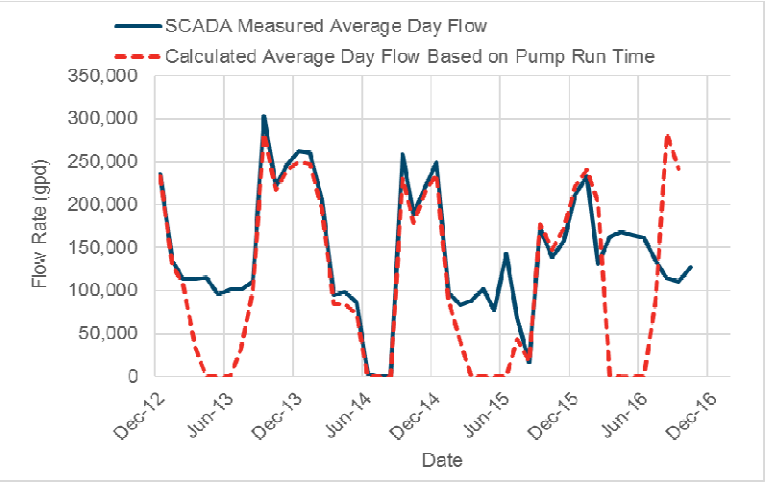
Nominal Pump Capacity= 1,330 gpm

Date	Min	Average	Max	Calculate Average Flow	Date	Min	Average	Max	Calculate Average Flow
	(hr/day)	(hr/day)	(hr/day)	(gpd)		(hr/day)	(hr/day)	(hr/day)	(gpd)
Jan-10	0	0	0	0	Jun-13	0	**0**	**0**	0
Feb-10	0	0	0	0	Jul-13	0	**0**	**0**	0
Mar-10	0	0	0	0	Aug-13	0	**0**	**0**	0
Apr-10	0	0	0	0	Sep-13	0	**0**	**0**	0
May-10	0	0.905806	14.58	72283.35484	Oct-13	0	**0**	**0**	0
Jun-10	0	15.864	24	1265947.2	Nov-13	0	**0**	**0**	0
Jul-10	0	0	0	0	Dec-13	0	**0**	**0**	0
Aug-10	0	0	0	0	Jan-14	0	**0**	**0**	0
Sep-10	0	0	0	0	Feb-14	0	**0**	**0**	0
Oct-10	0	0	0	0	Mar-14	0	**0**	**0**	0
Nov-10	0	0	0	0	Apr-14	0	**0**	**0**	0
Dec-10	0	0	0	0	May-14	0	**2.2112903**	**24**	0

Jan-11	0	0	0	0	Jun-14	0	**6.6576667**	**24**	0
Feb-11	0	0	0	0	Jul-14	0	**0**	**0**	0
Mar-11	0	0	0	0	Aug-14	0	**0**	**0**	0
Apr-11	0	0	0	0	Sep-14	0	**0**	**0**	0
May-11	0	0	0	0	Oct-14	0	**0**	**0**	0
Jun-11	0	0	0	0	Nov-14	0	**0**	**0**	0
Jul-11	0	0	0	0	Dec-14	0	**0**	**0**	0
Aug-11	0	0.005806	0.18	463.3548387	Jan-15	0	**0**	**0**	0
Sep-11	0	0.425	4.15	33915	Feb-15	0	**0**	**0**	0
Oct-11	0	1.134516	2.77	90534.3871	Mar-15	0	**0**	**0**	0
Nov-11	0	0.807	2.35	64398.6	Apr-15	0	**6.6843333**	**24**	0
Dec-11	0	0.132581	0.98	10579.93548	May-15	0	**13.834839**	**24**	0
Jan-12	0	0	0	0	Jun-15	0	**0**	**0**	0
Feb-12	0	0	0	0	Jul-15	0	**0**	**0**	0
Mar-12	0	0	0	0	Aug-15	0	**0**	**0**	0
Apr-12	0	0	0	0	Sep-15	0	**0**	**0**	0
May-12	0	0	0	0	Oct-15	0	**0**	**0**	0
Jun-12	0	0	0	0	Nov-15	0	**0**	**0**	0
Jul-12	0	0	0	0	Dec-15	0	**0**	**0**	0
Aug-12	0	0	0	0	Jan-16	0	**0**	**0**	0
Sep-12	0	0	0	0	Feb-16	0	**0**	**0**	0
Oct-12	0	0	0	0	Mar-16	0	**0**	**0**	0
Nov-12	0	0	0	0	Apr-16	0	**0**	**0**	0
Dec-12	0	0	0	0	May-16	0	**0**	**0**	0
Jan-13	0	0	0	0	Jun-16	0	**0**	**0**	0
Feb-13	0	0	0	0	Jul-16	0	**0**	**0**	0
Mar-13	0	0	0	0	Aug-16	0	**0**	**0**	0
Apr-13	0	0	0	0	Sep-16	0	**0**	**0**	0
May-13	0	0	0	0	Oct-16	0	**0**	**0**	0

Pump IP-1 Run Times



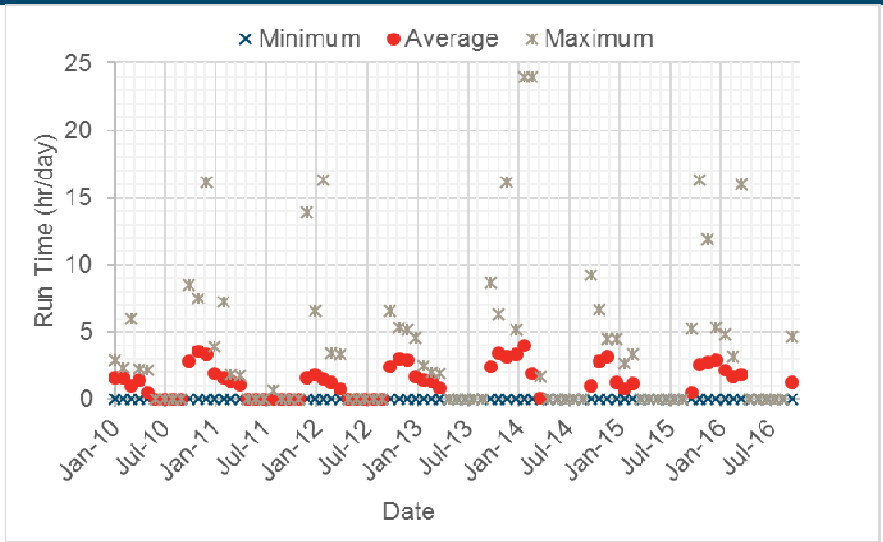


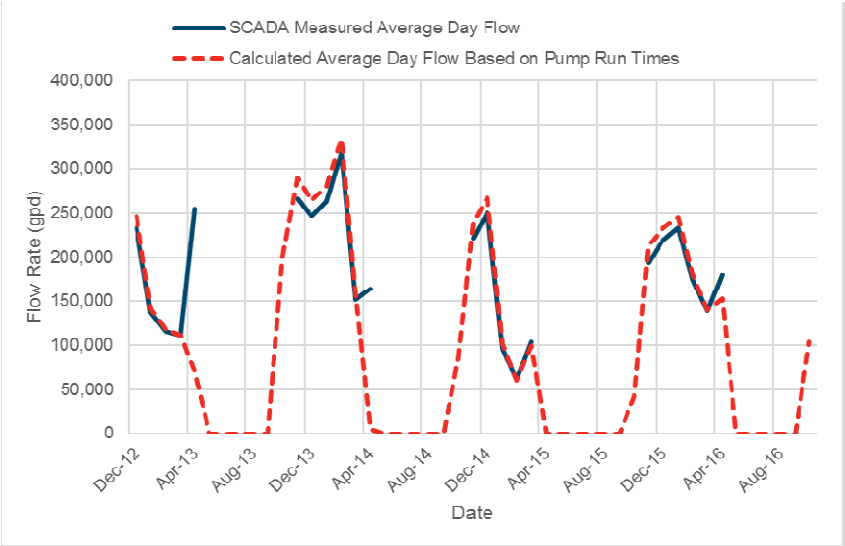
Nominal Pump Capacity= 1,400 gpm

Date	Min	Average	Max	Calculate Average Flow	Date	Min	Average	Max	Calculate Average Flow
	(hr/day)	(hr/day)	(hr/day)	(gpd)		(hr/day)	(hr/day)	(hr/day)	(gpd)
Jan-10	0	0	0		Jun-13	0		0	0
Feb-10	0	0.206786	1.12		Jul-13	0	0.380968	1.72	32,001
Mar-10	0	0.942903	3.72		Aug-13	0	1.205484	3.65	101,261
Apr-10	0	0	0		Sep-13	0	3.360667	5.47	282,296
May-10	0	0	0		Oct-13	0	2.580968	5.67	216,801
Jun-10	0	0	0		Nov-13	0	2.850667	5.52	239,456
Jul-10	0	0	0		Dec-13	0	2.971935	4.68	249,643
Aug-10	0	0	0		Jan-14	0	2.945484	4.58	247,421
Sep-10	0	2.467667	5.38		Feb-14	0	2.326429	4.35	195,420
Oct-10	0	0.400323	1.15		Mar-14	0	1.008065	1.55	84,677
Nov-10	0	1.331667	2.88		Apr-14	0	1.001	1.5	84,084
Dec-10	0	1.262581	2.83		May-14	0	0.865806	1.45	72,728
Jan-11	0	1.687097	3.3		Jun-14	0		0	0
Feb-11	0	1.365714	2.23		Jul-14	0		0	0
Mar-11	0	0.253226	1.58		Aug-14	0		0	0

Apr-11	0	0	0		Sep-14	0	2.739667	7.7	230,132
May-11	0	0	0		Oct-14	0	2.121613	7.98	178,215
Jun-11	0	0	0		Nov-14	0	2.568	5.78	215,712
Jul-11	0	0	0		Dec-14	0	2.795161	4.03	234,794
Aug-11	0	0	0		Jan-15	0	1.061613	3.88	89,175
Sep-11	0	0	0		Feb-15	0	0.483214	2.47	40,590
Oct-11	0	0	0		Mar-15	0		0	0
Nov-11	0	0	0		Apr-15	0		0	0
Dec-11	0	0.437419	3.2		May-15	0		0	0
Jan-12	0	0	0		Jun-15	0		0	0
Feb-12	0	0	0		Jul-15	0	0.522581	2.98	43,897
Mar-12	0	0	0		Aug-15	0	0.204839	1.57	17,206
Apr-12	0	0	0		Sep-15	0	2.116667	4.9	177,800
May-12	0	0.004333	0.13		Oct-15	0	1.759677	4.98	147,813
Jun-12	0	0	0		Nov-15	0	2.057333	5	172,816
Jul-12	0	0.881935	2.57		Dec-15	0	2.637097	4.88	221,516
Aug-12	0	0.851613	2.65		Jan-16	0	2.860968	5.2	240,321
Sep-12	0	0	0		Feb-16	0	2.41069	14	202,498
Oct-12	0	2.180323	4.85		Mar-16	0	0.005484	0.17	461
Nov-12	0	2.719	5.03		Apr-16	0		0	0
Dec-12	0	2.776774	4.75	233249.0323	May-16	0		0	0
Jan-13	0	1.552258	4.25	130389.6774	Jun-16	0	0.002667	0.08	224
Feb-13	0	1.276429	2.28	107220	Jul-16	0	1.059032	7.27	88,959
Mar-13	0	0.409032	1.82	34358.70968	Aug-16	0	3.37	7.8	283,080
Apr-13	0		0	0	Sep-16	0	2.872333	4.83	241,276
May-13	0		0	0	Oct-16	0	3.844839	8.55	322,966

Pump IP-2 Run Times



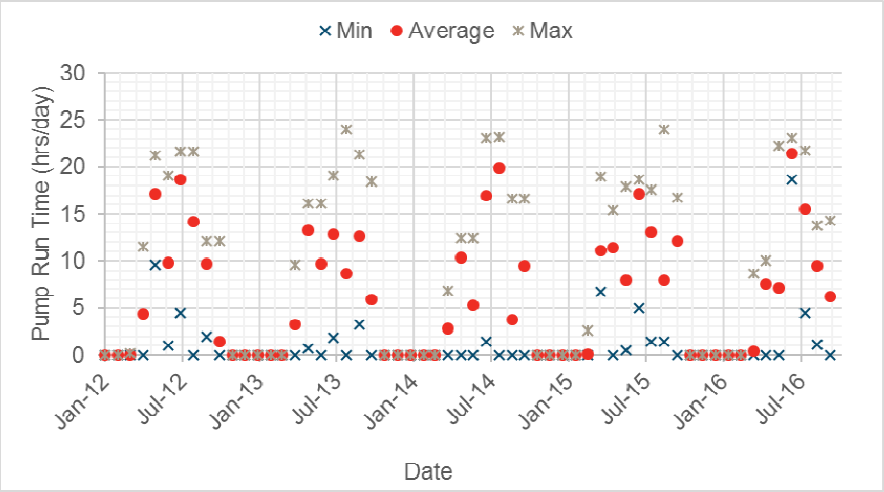


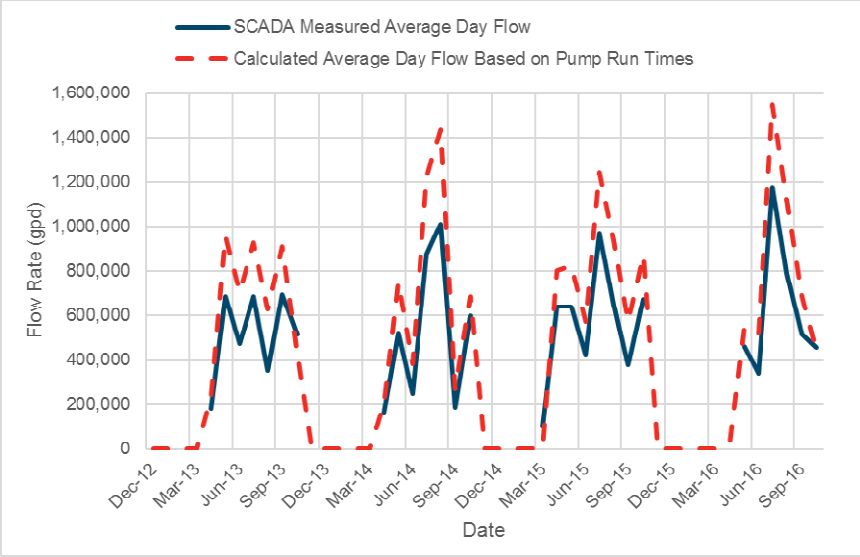
Nominal Pump Capacity= 1,400 gpm

Date	Min	Average	Max	Calculate Average Flow	Date	Min	Average	Max	Calculate Average Flow
	(hr/day)	(hr/day)	(hr/day)	(gpd)		(hr/day)	(hr/day)	(hr/day)	(gpd)
Jan-10	0	1.576774	2.92		Jun-13	0		0	0
Feb-10	0	1.5475	2.32		Jul-13	0		0	0
Mar-10	0	1.013226	5.97		Aug-13	0		0	0
Apr-10	0	1.371333	2.27		Sep-13	0		0	0
May-10	0	0.491935	2.2		Oct-13	0	2.388065	8.65	200,597
Jun-10	0	0	0		Nov-13	0	3.444667	6.35	289,352
Jul-10	0	0	0		Dec-13	0	3.139032	16.13	263,679
Aug-10	0	0	0		Jan-14	0	3.330968	5.18	279,801
Sep-10	0	0	0		Feb-14	0	3.979643	24	334,290
Oct-10	0	2.854194	8.48		Mar-14	0	1.888065	24	158,597
Nov-10	0	3.61	7.45		Apr-14	0	0.055	1.65	4,620
Dec-10	0	3.359355	16.17		May-14	0		0	0
Jan-11	0	1.880645	3.9		Jun-14	0		0	0
Feb-11	0	1.544286	7.25		Jul-14	0		0	0
Mar-11	0	1.302581	1.83		Aug-14	0		0	0

Apr-11	0	1.079667	1.73		Sep-14	0		0	0
May-11	0	0	0		Oct-14	0	1.022581	9.22	85,897
Jun-11	0	0	0		Nov-14	0	2.861667	6.65	240,380
Jul-11	0	0	0		Dec-14	0	3.18	4.52	267,120
Aug-11	0	0.032581	0.68		Jan-15	0	1.21	4.48	101,640
Sep-11	0	0	0		Feb-15	0	0.720357	2.67	60,510
Oct-11	0	0	0		Mar-15	0	1.18129	3.32	99,228
Nov-11	0	0	0		Apr-15	0		0	0
Dec-11	0	1.613226	13.85		May-15	0		0	0
Jan-12	0	1.859355	6.55		Jun-15	0		0	0
Feb-12	0	1.476552	16.28		Jul-15	0		0	0
Mar-12	0	1.212581	3.38		Aug-15	0		0	0
Apr-12	0	0.704667	3.35		Sep-15	0		0	0
May-12	0	0	0		Oct-15	0	0.503226	5.25	42,271
Jun-12	0	0	0		Nov-15	0	2.542	16.28	213,528
Jul-12	0	0	0		Dec-15	0	2.773871	11.93	233,005
Aug-12	0	0	0		Jan-16	0	2.922581	5.32	245,497
Sep-12	0	0	0		Feb-16	0	2.15069	4.83	180,658
Oct-12	0	2.416452	6.57		Mar-16	0	1.678065	3.12	140,957
Nov-12	0	2.95	5.3		Apr-16	0	1.815667	16	152,516
Dec-12	0	2.930645	5.17	246174.1935	May-16	0		0	0
Jan-13	0	1.688065	4.55	141797.4194	Jun-16	0		0	0
Feb-13	0	1.404286	2.5	117960	Jul-16	0		0	0
Mar-13	0	1.33	2.03	111720	Aug-16	0		0	0
Apr-13	0	0.840667	1.93	70616	Sep-16	0		0	0
May-13	0		0	0	Oct-16	0	1.232258	4.68	103,510

Irrigation Pump Run Times





Nominal Pump Capacity= 1,200 gpm

Date	Min	Average	Max	Calculate Average Flow	Date	Min	Average	Max	Calculate Average Flow
	(hr/day)	(hr/day)	(hr/day)	(gpd)		(hr/day)	(hr/day)	(hr/day)	(gpd)
Jan-10	0	0	0		Jun-13	0	9.764	16.1	703,008
Feb-10	0	0	0		Jul-13	1.88	12.83742	19.03	924,294
Mar-10	0	0	0		Aug-13	0	8.712258	24	627,283
Apr-10	0	0	0		Sep-13	3.2	12.64867	21.3	910,704
May-10	0	5.130645	12.17	369406.4516	Oct-13	0	5.855484	18.42	421,595
Jun-10	0	7.048333	12.15	507480	Nov-13	0	0	0	0
Jul-10	0.95	17.57839	23.57	1265643.871	Dec-13	0	0	0	0
Aug-10	12.77	20.99903	23.03	1511930.323	Jan-14	0	0	0	0
Sep-10	0	7.299333	18.07	525552	Feb-14	0	0	0	0
Oct-10	0	7.123871	18.08	512918.7097	Mar-14	0	0	0	0
Nov-10	0	0	0	0	Apr-14	0	2.815	6.87	202,680
Dec-10	0	0	0	0	May-14	0	10.34806	12.47	745,061
Jan-11	0	0	0	0	Jun-14	0.03	5.26	12.43	378,720
Feb-11	0	0	0	0	Jul-14	1.48	16.96903	23.08	1,221,770
Mar-11	0	0	0	0	Aug-14	0	19.88677	23.12	1,431,848

Apr-11	0	0.175667	5.27	12648	Sep-14	0	3.700667	16.67	266,448
May-11	0	11.94258	17.5	859865.8065	Oct-14	0	9.529677	16.7	686,137
Jun-11	0	5.263	14.87	378936	Nov-14	0	0	0	0
Jul-11	0	16.96645	24	1221584.516	Dec-14	0	0	0	0
Aug-11	0	17.55	24	1263600	Jan-15	0	0	0	0
Sep-11	0	14.237	24	1025064	Feb-15	0	0	0	0
Oct-11	0	7.295161	20.12	525251.6129	Mar-15	0	0.084839	2.63	6,108
Nov-11	0	0	0	0	Apr-15	6.7	11.118	18.98	800,496
Dec-11	0	0	0	0	May-15	0	11.41774	15.43	822,077
Jan-12	0	0	0	0	Jun-15	0.48	7.930667	17.92	571,008
Feb-12	0	0	0	0	Jul-15	5.02	17.22677	18.6	1,240,328
Mar-12	0	0.007419	0.23	534.1935484	Aug-15	1.5	12.99613	17.62	935,721
Apr-12	0	4.362333	11.53	314088	Sep-15	1.47	7.926333	24	570,696
May-12	9.6	17.21333	21.18	1239360	Oct-15	0	12.07484	16.78	869,388
Jun-12	1	9.826667	19.02	707520	Nov-15	0	0	0	0
Jul-12	4.5	18.63935	21.6	1342033.548	Dec-15	0	0	0	0
Aug-12	0	14.13774	21.62	1017917.419	Jan-16	0	0	0	0
Sep-12	2	9.716333	12.1	699576	Feb-16	0	0	0	0
Oct-12	0	1.493871	12.1	107558.7097	Mar-16	0	0	0	0
Nov-12	0	0	0	0	Apr-16	0	0.449	8.72	32,328
Dec-12	0	0	0	0	May-16	0	7.607742	10.03	547,757
Jan-13	0	0	0	0	Jun-16	0	7.189333	22.2	517,632
Feb-13	0	0	0	0	Jul-16	18.63	21.45806	23.02	1,544,981
Mar-13	0	0	0	0	Aug-16	4.48	15.48935	21.75	1,115,234
Apr-13	0	3.175333	9.58	228624	Sep-16	1.18	9.501	13.8	684,072
May-13	0.75	13.26129	16.13	954812.9032	Oct-16	0	6.165806	14.28	443,938

EXISTING LAGOON CONDITION EVALUATION

Belgrade Wastewater Master Plan
Existing Treatment Lagoon Water Balance (Nov 2015 to Jan 2016)
TD&H Job No. B16-048

Treat Lagoons Overall Area= 29.8 acres
1,298,088 SF

Date	Inflow					Outflow					In-Out
	Influent		Precipitation		Total	IP SCADA (3)		Irrigation SCADA (4)		Total	
	(gal)	(CF)	(IN)	(CF)	(CF)	(gal)	(CF)	(gal)	(CF)	(CF)	(CF)
November-16	22,936,037	3,066,315	0.22	23,798	3,090,113	2,887,469	386,025	3,902,808	521,766	907,791	2,182,322
December-16	22,984,056	3,072,735	0.69	74,640	3,147,375	3,077,069	411,373	4,790,078	640,385	1,051,758	2,095,617
January-17	11,036,339	1,475,446	0.09	9,736	1,485,182	1,702,093	227,553	1,516,014	202,676	430,228	1,054,954

(1) Evaporation assumed to be zero in the winter months
(2) Precipitation Data from the Galatian Field Airport WRCC Data
(3) SCADA IP data is the flow to IP beds "A" and "B"
(4) SCADA Irrigation data is the flow to IP bed "C" and the Irrigation system

Date	Initial Depth		Final Depth		Change in Depth	Change in Water Volume	
	Depth	Water Surface Area	Depth	Water Surface Area		Average End Area Method	Conic Approximate Method
	(ft)	(SF)	(ft)	(SF)	(ft)	(CF)	(CF)
November-16	3.57	488,104.68	5.03	501,547.77	1.46	722,446.29	722,424.07
December-16	5.25	503,586.75	6.87	518,708.35	1.62	828,059.03	828,028.83
January-17	6.87	518,708.35	7.8	527,474.64	0.93	486,475.09	486,469.40

(1) Meters appeared to have malfunctioned between 1:18 PM on Nov 29 to 9:24 AM on December 2.
(2) Treatment pond depth stayed constant at 2.19 ft. Recorded depths represent storage pond depths.
(3) January values from January 1, 2017 to January 13, 2017

Bottom of pond Area= 455880 SF
Length= 1048 FT
Width= 435 FT
Side Slope 3 Horizontal
1 Vertical

Date	Inflow	Adjusted Inflow	Outflow	Change in Pond Volume (2)	Unaccounted for Water	% Unaccounted for	Overall Seepage (1)	
	(CF)	(CF)	(CF)	(CF)	(CF)		(inches/day)	(inches/year)
November-16	3,090,113	2,218,268	907,791	722,446	588,031	26.5%	0.181	66.1
December-16	3,147,375	2,273,704	1,051,758	828,059	393,887	17.3%	0.121	44.3
January-17	1,485,182	1,065,668	430,228	486,475	148,965	14.0%	0.046	16.8

(1) Uses overall water surface area
(2) Used Average End Area Method for Change in Volume

- Performance Evaluations
- Troubleshooting & Optimization
- Hydraulics Optimization
- Training

H&S Environmental, LLC.

2122 East Leland Circle Mesa, AZ 85213 1 (480) 274-8410

Date: September 11, 2015

Paul Lavigne
Section Supervisor
TFAB-Water Pollution Control Revolving Fund
1520 East Sixth Ave
P.O. Box 200901
Helena, MT 59620-0901
1 (406) 444-5337

Re: Performance Evaluation of the Belgrade, Montana STP

Paul,

Enclosed is the September 11, 2015 report for H&S Environmental's (H&S) performance evaluation of the of the Belgrade STP

The purpose of this report is to identify operational conditions and practices that should prevail to keep the Belgrade pond system in long term sustained Total Nitrogen (TN) compliance.

All facility data, sludge depth data, and other field data used in this report were compiled by Montana DEQ, H&S Environmental, LLC, and Belgrade City personnel. The conclusions reached in this performance evaluation are based on photos, field notes, observations, testing, and then interviews with City personnel and the DEQ. Discussions about site visits by DEQ with H&S Environmental, LLC (H&S) also played an important part of this evaluation. The compliance history and statistical analysis for the Belgrade STP were based on compliance data for the past thirteen (13) years and one (1) month from May 31, 2002 through June 30, 2015, (13.01 years).

The site visit of July 20, 2015 showed the approaching need for sludge removal from treatment Cell # 1 as sludge occupies about eighteen (18) percent of this cells treatment capacity with an average sludge blanket thickness of 1.55 feet. Since April, 2012 the Belgrade STP has had excessively high BODs…a possible indication of nitrification in the BOD bottle meaning too much ammonia is leaving the system pushing the effluent Total Nitrogen discharge numbers up.

Outlined in this report are a number of recommendations that address opportunities to optimize the performance of the Belgrade wastewater stabilization pond system for long term sustained compliance.

Thank you.

Sincerely,

Steve Harris
President
H&S Environmental, LLC

PERFORMANCE EVALUATION REPORT

Facility Name: Belgrade Sewer Treatment Plant (STP)

Client: Montana Department of Environmental Quality.
1520 East Sixth Ave
Helena, Montana 59620

Date of Field Inspection: July 20, 2015
Data Review: Compliance Sample Data from ICIS EPA May, 2002 to June, 2015
USEPA ECHO data from December, 2012 to June, 2015
Data from Field Grab Samples by H&S Environmental
& MTDEQ on July 20, 2015
Dissolved Oxygen & pH sampling by H&S and Belgrade City Personnel
Lab Analysis by: The State of Montana DHHS

Inspection Participants:
Montana DEQ: Bill Bahr & Dave Frickey

City of Belgrade: Steven Klotz

H&S Environmental, LLC: Steve Harris

Report Prepared By:
Steve Harris,
President, H&S Environmental, LLC
September 11, 2015

Section 1

Introduction and Background

1.0 Scope and Purpose

In January of 2014 H&S Environmental, LLC began discussions with MDEQ and about methods that could be used to optimize Montana wastewater stabilization pond systems to meet long term sustained compliance. After several discussions a review of the data, and a field visit Steve Harris of H&S Environmental, LLC prepared a performance review of the Belgrade STP.

The information used in this performance and optimization evaluation for sustained long term compliance includes the following:

- Interviews with MDEQ & on the general condition of the lagoon system
- Reviews of grab sample results by the State of Montana DHHS Environmental Laboratory
- A review of 2002 through 2015 effluent sampling results recorded in USEPA's ICIS database and USEPA ECHO database information from December, 2012 to June, 2015
- Review of on-site inspection and testing of the Belgrade pond system on July 20, 2015
- Reviews of operations and sampling protocols, and MDEQ's own test results
- A review of the Town of Belgrade's own information

The purpose of this evaluation is to identify ways to improve the treatment process to continue to meet Total Nitrogen (TN) permit requirements in a long term sustained manner.

The focus of this report then is to offer solutions to keep TN under permit limitations by optimizing in-pond nitrogen removal. To determine if in-pond optimization is possible H&S Environmental will analyze and evaluate lagoon system performance with respect to (i) historical data reviewed, (ii) additional data gathered from special testing, (iii) samples gathered from the on-site visit by MDEQ & H&S and (iv) a review of sampling and testing protocols practiced by Belgrade personnel.

This report covers the performance of the Belgrade STP system as it existed up to June 30, 2015. Throughout this report it is important to remember that Total Nitrogen (TN) is composed of Ammonia, Organic Nitrogen, Nitrate and Nitrite. Lowering any one of the constituent parts of TN will result in the lowering of TN concentrations as a whole.

Section 2 – Findings

2.0 Findings

Based on the results of thirteen (13) years and one (1) month (13.08 years) of wastewater data analyzed from May 31, 2002 to June 30, 2015 and specialized on-site testing, the following conclusions can be made about the Belgrade STP wastewater lagoon system:

1. In terms of permit compliance the Belgrade system is fully compliant in terms of lbs. /day of Total Nitrogen (TN) discharged. TN is the City of Belgrade's only permit limitation. All other water quality indicators recorded are merely tested and recorded for monitoring purposes only and can be used for process control to keep TN within limits. Average effluent BOD for the past two and a half (2 ½) years as recorded in ECHO is 22.89 mg/l. BOD reduction to 22.89 mg/l equates to an overall BOD_5 removal efficiency of 93.8% based on a two and a half (2 ½) year average influent BOD of 374 mg/l. There is an increasing trend in effluent BOD. This could mean that increasing levels of organic nitrogen or ammonia are leaving the plant to raise the effluent TN levels. The average 2 ½ year effluent TSS results are 28.54 mg/l with an increasing yearly trend. The trend in effluent TSS is on the rise. This could lead to increased TN through increased organic nitrogen concentrations. A water quality spot check was made on July 20, 2015 and yielded an effluent COD of 84.2 and a filtered COD of 64.4 indicating algae on this day may be contributing about 26.4 mg/l to the effluent BOD results. COD is typically 1.99 times the effluent BOD for municipal systems.

2. Based on the average ECHO compliance data flow-rate of .568 MGD, an average actual (measured) water depth of 8.85 feet, and a 3:1 slope, the average total theoretical detention time of this system is 170 days. With sludge accumulation this total theoretical retention time is brought down by 18% to 25% , to an actual retention time of 127.5 days. At 374 mg/l influent BOD_5 (USEPA ECHO average) and a flow of .568 MGD, loading to this system is 1,772 lbs. / BOD /day. Sized at 12.80 acres the loading to the primary treatment cell is 138.4 lbs./ac/day. This is probably right where loading to an aerated lagoon under Belgrade's weather conditions should be.

3. During a field sampling visit on the morning of July 20, 2015 at 9:00 AM dissolved oxygen concentrations in the primary treatment cell ranged from .01 to .40 mg/l. This suggests that the system runs anoxic during most of the evening and early morning hours in the primary treatment cell. In the afternoon DO concentrations lifted to a little over 1 mg/l. Loading to this cell may be too high to sustain constant aerobic conditions. Average dissolved oxygen concentrations to an aerobic cell should be above two (2) mg/l at all times to maintain aerobic conditions. DO concentrations recovered nicely to levels over 12 mg/l in Cell # 3 during the afternoon. This suggests the possibility of recirculating highly oxygenated water from the final treatment cell back to the primary cell during certain times of the year and certain times during the day.

4. From April 2012 to June, 2015 the trend in the effluent BOD_5 is up. The last recorded effluent BOD for Belgrade was 165 mg/l and before that 85 mg/l. This may be an indication of too much ammonia leaving the system. Regular CBOD and filtered BOD (SBOD) should be run with the routine BOD samples to determine the source of the BOD for potential TN reduction. Please see Diagnostic BODs in the material attached to this report for more explanation.

Section 2 – Findings - Continued

6. From 2012 to 2015 effluent TSS concentrations are up with an average 2 ½ year effluent TSS concentration of 28.55 mg/l.

7. Sludge has accumulated 1.55 feet in the primary treatment cell. An accumulation of 1.55 feet of sludge represents a treatment capacity loss of about eighteen (18) percent depending upon where "normal" operating depths are. Retention time is being lost because of sludge accumulation. Typically sludge is removed in a system when it has reached eighteen (18) inches or more. Removal at this level is to prevent nutrient feedback that causes excessive algae bloom, high TSS, and nitrogen permit limit failures. There is a total of 5,583,929 gallons of sludge in Cell # 1. The City of Belgrade should consider removing sludge in this system as a way to reduce effluent TN discharges.

8. Using regression analysis to predict TSS shows the following:

- BOD eff has no statistically significant effect on TSS effluent
- Flow has no statistically significant effect on TSS effluent
- TSS eff tends to be larger for larger Total Nitrogen
- TSS eff tends to be larger for smaller Nitrogen, ammonia total [as N]
- TKN has no statistically significant effect on TSS eff
- Phosphorus, total [as P] has no statistically significant effect on TSS

Statistical analysis of the two and a half years of the Belgrade ECHO data set shows BOD and TSS are ***not*** positively correlated (t test) as is typical in most systems. Over the last three (3) months nitrification in the BOD test bottle could have destroyed this correlation. When TSS and BOD are correlated anything that can be done to reduce or remove TSS will also reduce BOD. Diagnostic BODs, especially a CBOD in this case, and a microscopic examination of the effluent would be helpful to understand fully the source of the TSS and cause of the excessively high effluent BOD in this system to keep TN numbers low and compliant over the long term.

Section 3 – Recommendations

RECOMMENDATIONS

Based on the results of 13 years of effluent data analyzed, site visits, specialized intra-pond BOD_5 testing, and sludge profiles, below are recommendations for improved stabilization pond performance for long term sustained compliance using the existing wastewater pond system.

Secondary treatment standards are consistently being met with respect to lbs/day of discharged Total Nitrogen (TN). Based on the results of grab samples and an upward trend in BOD and TSS there is a strong possibility that too much ammonia is leaving the system for the potential to violate TN permit limits over the long term.

Semi-annual or quarterly intra-pond BOD_5, $CBOD_5$, Filtered BOD_5, Dissolved Oxygen, Microscans and ammonia testing should be conducted to identify the exact source of the BOD and TSS leaving the pond system for continued TN control.

Section 3 – Recommendations - Continued

Four (4) recommendations for continued lagoon system TN compliance are:

1. Remove sludge from Cell # 1 for load reduction, nutrient suppresion and enhanced (restored) treatment capacity
2. Increase aeration during the evening hours
3. Add a recirculation system
4. Consider adding an effluent multiple level drawoff structure to pull water from deeper in the water column to lower algae concentrations in the effluent because algae add to the TN results.

1) Sludge removal.

In the Belgrade system sludge has accumulated to the point where removal should be considered. Not only does sludge replace valuable treatment capacity (18% in Belgrade's case) but it also stores and releases nutrients (TN) back into the water column. At about 18 inches of accumulated sludge some states require sludge removal because the stored nutrients in the sludge release CO_2, ammonia, nitrates, phosphates, and organic acids back to the water column to feed algae cells and cause recurring algae bloom resulting in raising BOD and TSS for potential TN violations.

With accumulated sludge at the 1.55 foot level (18.6 inches), the sludge in the Belgrade system may be effecting treatment performance by oozing nutrients back into the water column. Engineers with the states of Vermont and New Hampshire have done research on nutrient release from sludge in pond systems and have proven that sludge blankets over 18 inches cause benthal feedback problems resulting in persistent TSS violations because the sludge feeds new algae growth. Sludge accumulation is not appreciably affecting treatment capacity in Cell # 1 where a 7.3 foot water cap remains to settle solids and treat for nutrient removal.

2) Adding More Air During the Evening Hours

Cell # 1 should be removing eighty (80) percent of the influent BOD. If it can do this then subsequent cells can use their treatment capacity to remove nutrients, settle solids, and kill pathogens. Adding more air may help remove more ammonia which may be causing the excessively high BOD measured and recorded over the last three (3) months. Under anoxic conditions nitrifying bacteria cannot thrive to remove ammonia. As ammonia and nitrifying bacteria get into the BOD test bottle for five days under ideal conditions, they can wreak havoc with the effluent BOD results. Measure Cell # 1 effluent to determine if it is reducing plant BOD load by 80%. At the same time measure Cell # 1's effluent ammonia. The Belgrade system does in fact nitrify as evidenced by the ammonia reduction and then nitrate production through the treatment system.

Consistently aerobic conditions are necessary to allow the system to completely nitrify. Cycles of air / no air make it difficult to establish an efficient population of nitrogen removing microorganisms. These types of microbes require consistent conditions to establish themselves as part of a working food web capable of removing pollutants.

Section 3 – Recommendations - Continued

3) Add Recirculation as a Source of Oxygen and a way to Reduce Nitrates

Nitrate is composed of nitrogen and oxygen. The oxygen part of the NO_3 molecule is, and can be, an oxygen source for hungry microbes. Recirculation is a way to bring oxygen in the form of nitrate back to the Primary Cell where oxygen is needed the most. From the 2011 EPA Manual on Lagoons we read: "Pond recirculation involves inter- and intra-pond recirculation as opposed to mechanical mixing in the pond cell. The effluents from pond cells are mixed with the influent to the cells. In intra-pond recirculation, effluent from a single cell is returned to the influent to that cell." Recirculation is accomplished using high-volume, low-head propeller pumps keeping recirculation an inexpensive option to nitrogen reduction. Newly constructed lagoon systems are built with recirculation systems designed into them because over the years they have proven to be very effective at oxygenating overloaded systems. Recirculation is a cost effective way to add oxygen to a lagoon as algae are much more efficient at generating the dissolved oxygen necessary for aerobic oxidation than are mechanical aerators. Recirculation also returns nitrates (NO_3) as an oxygen source and as a way to reduce this particular pollutant for TN reduction. The Belgrade system when field tested had effluent nitrates in the 12 mg/l range.

Typically recirculation is run during the daylight to early evening hours and never during the winter. A dissolved oxygen meter or Nitrate test strip dictates when the recirculation system is turned on and off. About $1/10^{th}$ of the daily flow is recirculated on any given day.

4) Adding a Multiple Level Draw-off Structure to Lower Effluent TSS

Algae will typically grow in the upper two (2) to three (3) feet of the water column of a lagoon system. This zone of course is typically where the TSS will be the highest. Algae concentrations are the highest here because that is where light penetrates to feed algae cells. Below this level water tends to become less turbid because there are fewer algae cells. Nitrogenous compounds are tied up in algae cells so discharging as few cells as possible is a way to reduce the organic nitrogen fraction of the TN. To perform the TN test, an effluent sample is digested in an alkaline persulfate digestion process to oxidize all nitrogenous compounds into nitrate. Fewer algae cells…less TN.

A multiple level draw-off structure is a discharge structure that allows operators to select the level where water is the clearest. An operator lowers a clear plastic tube down into the water column, raises it and then determines where the water is the clearest. Valves are set to this level. At the same time he also lowers a dissolved oxygen and pH probe down to confirm the water quality and then fine tunes the valving on the multiple level draw-off structure to pull water from the "sweet spot" in the water column.

5) Sand Filtration for Organic Nitrogen Control

Cheaper than an activated sludge system and easier to run are sand filters for algae removal. It is widely accepted that algae concentrations of greater than 3-5 x 10^5/ml generally causes an effluent BOD_5 concentration of greater than 30 mg/L. For future compliance a sand filter may be required to meet permit limits. To confirm this fact, a simple filtered or soluble carbonaceous (SCBOD) test should be performed. This is a testing procedure where the effluent BOD_5 sample is run and the sample split, so the other half of the BOD sample can be passed through a TSS filter first before running the second BOD test. Comparing the BOD to the Filtered BOD (SBOD) will indicate algae's influence on the TN test results and prove the need or

Section 3 – Recommendations - Continued

not to separate algae as part of some tertiary treatment strategy. Please see paper on Sand Filters and Multiple Level Draw Off that is accompanies this report.

6) <u>Adding Aeration</u>

During the process of oxidizing the waste that enters the pond system, carbon dioxide (CO_2) is generated. CO_2 is a major source of nutrition for algae cells and feeds algae blooms when CO_2 is present. If shaken, the CO_2 in a bottle of soda leaves and the soda goes flat. Just like a bottle of soda if a pond is shaken with aeration or mixing the CO_2 that has been produced by the system will be driven out of the water column because CO_2 has a low solubility in water. Continuing to aerate Cells 1, 2, & 3 can strip CO_2 from the system to discourage algae growth for TN reduction.

There is some indication that in the past the Belgrade STP nitrifies during certain times of the year. Because of this it is wise to also run CBOD along with the BOD tests currently run if dissolved oxygen profiles are showing numbers less than 1 mg/l. NBOD (the difference between BOD and CBOD) is an indicator that more air is needed up stream of the effluent to oxidize ammonia to nitrate.

There is no permit limit for BOD_5. Excessively high BODs when used as an indicator are typically caused by four (4) things:

1. Nitrification in the BOD test bottle
2. Algae respiring (consuming oxygen under dark conditions in the BOD_5 bottle over 5 days)
3. SCBOD…Dead decaying algae on the surface or in the chlorine contact chamber or sludge, releasing organic matter from the sludge blanket into the BOD test bottle
4. Gross short circuiting causing the influent to pass to the effluent in a short amount of time.

Total Nitrogen (TN) is the sum of nitrate (NO_3), nitrite (NO_2), organic nitrogen (algae and bacteria cells) and ammonia (all expressed as N). Note that for laboratory analysis purposes, Total Kjeldahl Nitrogen (TKN) is a test performed that is made up of both organic nitrogen and ammonia.

BOD and TSS can be used as an indicator to understand biochemically what is happening in a pond system. To this end it is advisable to run diagnostic BODs to determine the nature of the effluent TSS and BOD. For one month during the winter of 2015 or the summer of 2016 run weekly BOD, CBOD, Filtered BOD, Filtered CBODs **<u>and</u>** ammonia from the effluent of the system. These four BOD tests run on effluent samples will tell Belgrade operations personnel exactly the cause and source of the TSS. These tests are powerful in that they will tell operations **WHERE** and **WHY** problems are occurring. These tests are powerful preventative measures to staying in compliance. Please see ***Diagnostic BODs*** in the attachments section.

Section 4 – Data Analysis

Data Analysis

Sludge Accumulation

Aside from occupying valuable capacity and lowering a treatment cell's retention time, sludge releases nutrients and soluble BOD back into the water column to feed algae. Once it reaches about eighteen (18) inches in thickness it is time to consider removal to maintain compliance. Seen below is a sludge blanket profile of Belgrade's Cell # 1 compiled from field data collected on July 20, 2015.

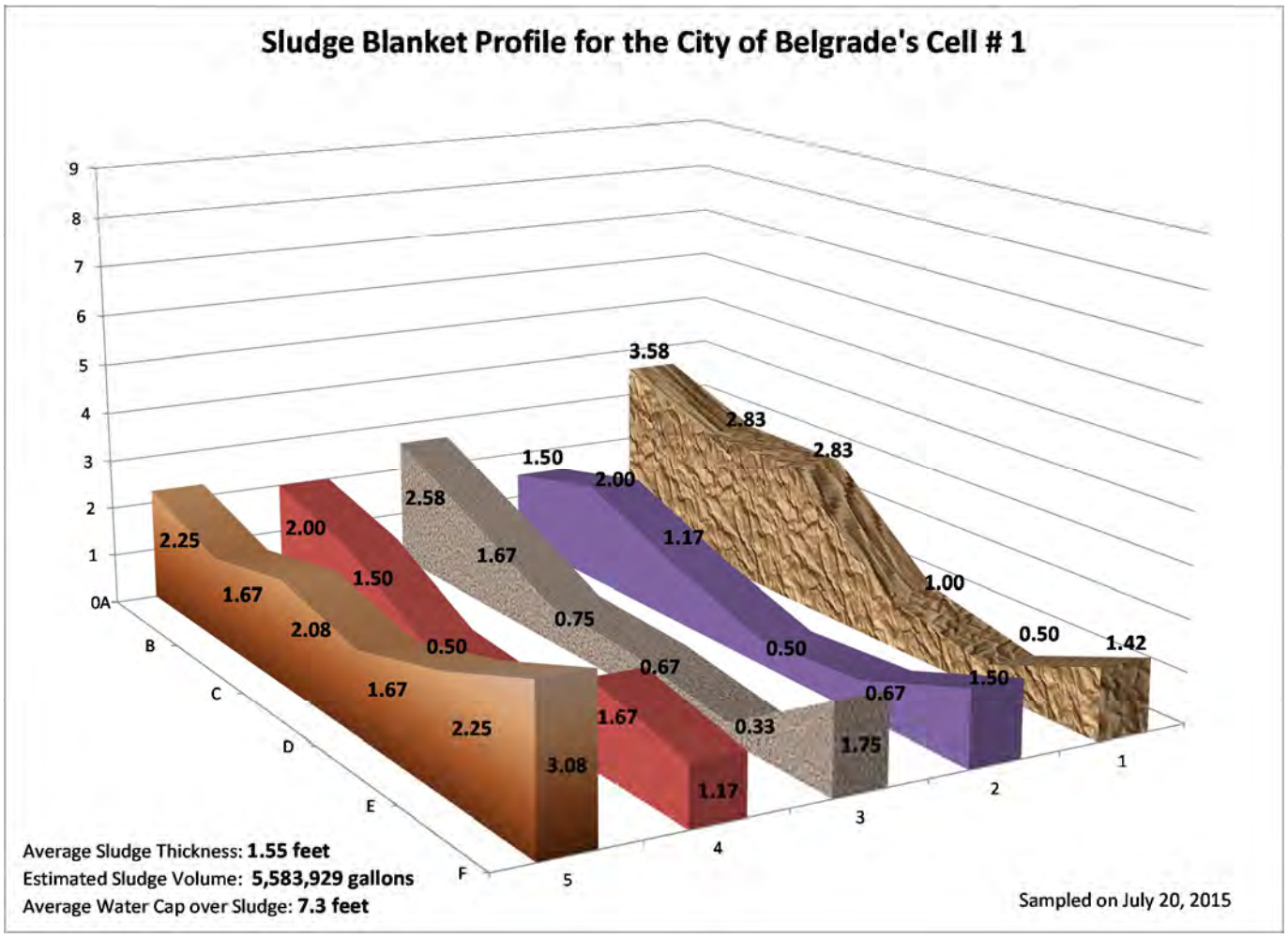


Figure 1. Cell # 1 Sludge Blanket Profile

Eighteen (18) percent of the capacity of this treatment cell has been displaced by sludge. Because of this and the low dissolved oxygen levels, sludge removal should be considered.

Over time sludge will slough off and enter the effluent to cause elevated TSS. More detrimental however are the nutrients that are released from the sludge that cause TN violations and recurring algae blooms for ever- worsening TSS problems.

Section 4 – Data Analysis Cont-

A sludge blanket can actually create an oxygen demand. Dr. Lynville Rich (Rich, 1999) has developed a formula to calculate oxygen demand based on sludge volume. 5,583.929 gallons of sludge is reducing capacity and effecting performance in the Belgrade STP system.

According to Dr. Lynnville G. Rich (Rich, 1999) the formula for determining a lagoon's sludge oxygen demand is:

Ro_2 in Kg O_2/hr = 4.16 x 10^{-5} ABo_2 where:

- Ro_2 = benthal oxygen demand rate in Kg O_2/hr
- A = Area of sludge water interface in m^2
- Bo_2 = Unit rate of benthal oxygen demand in g $O_2/m^2/d$

Assuming the following:

- an average BOD_5 of 374 mg/l,
- an average daily flow of .568 MGD
- a sludge water interface of 8,400 m^2
- a benthal oxygen demand of 80 $g/m^2/d$
- Lagoon # 1 dimensions: (1071.2' x 456.2') = 488,681 ft^2 or 45,314 m^2)
- Benthal oxygen demand: 80 $g/m^2/d$. Dr. Rich suggests using this value when determining aeration requirements. (Rich, 1999)

The sludge oxygen demand for Cell # 1: 331 lbs. O_2/day calculated as follows:

Ro_2 = 4.16 x 10^{-5} x (45,314 m^2) x (80 $g/m^2/d$) x 2.20 lbs. /Kg = **<u>331 lbs. O_2 /day</u>**

Other researchers put the sludge oxygen demand (SOD) at 3 g/m^2 which gives an SOD or **300 lbs. /day** Based on oxygen demand to satisfy influent BOD_5 at 374 mg/l and ammonia oxygen demand at 20 mg/l influent NH_4^+, the total oxygen requirement for just the influent load alone is **<u>4000 lbs. /day.</u>**

Algae also contribute to the oxygen supply through photosynthesis. From the numbers above the sludge oxygen demand can be significant. This may be one of the reasons the Belgrade system runs anoxic through most of the evening and early morning hours.

Section 4 – Data Analysis Cont-

Past satellite photos show good wind activity over the surface of the pond system. On July 20, 2015 the Belgrade system had low levels of dissolved oxygen (DO) in the morning hours with DO fully recovered in the final cell in the late morning.

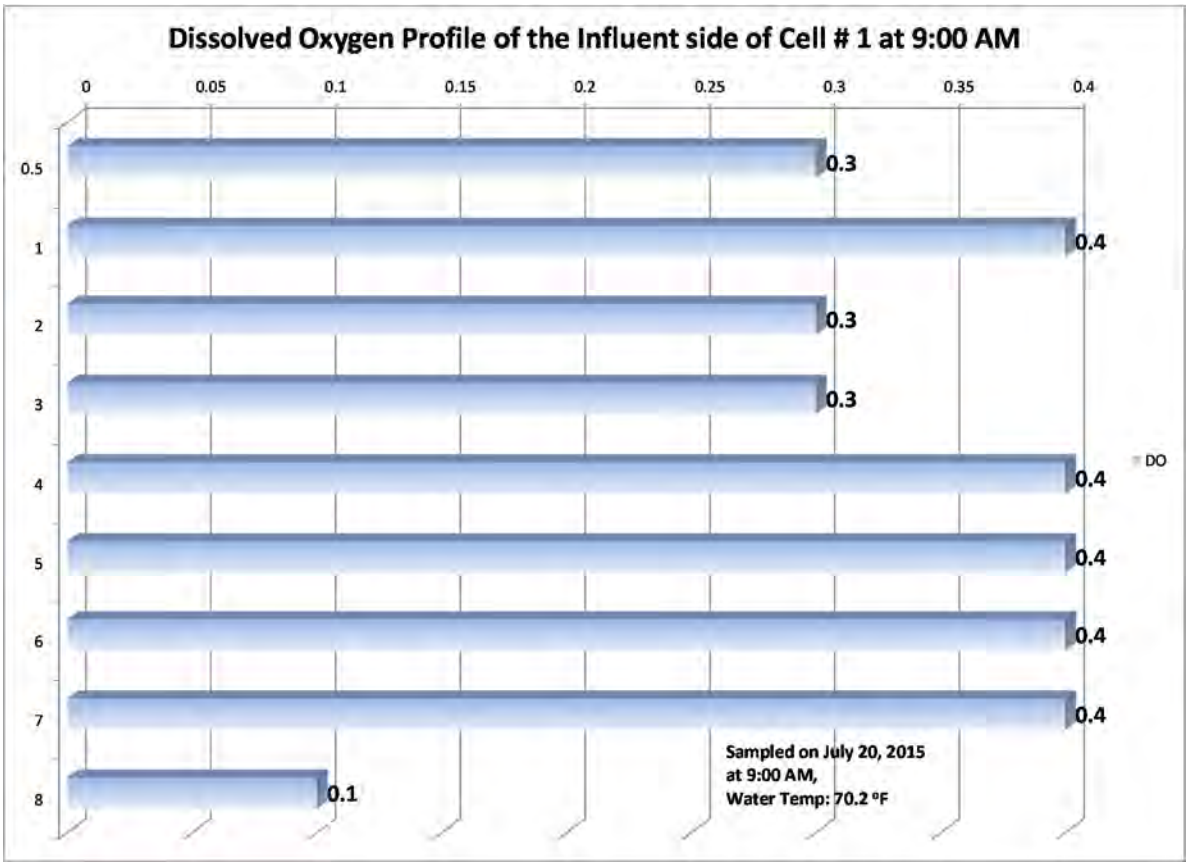


Figure 3. Belgrade's Morning Time Cell # 1 Dissolved Oxygen Profile.

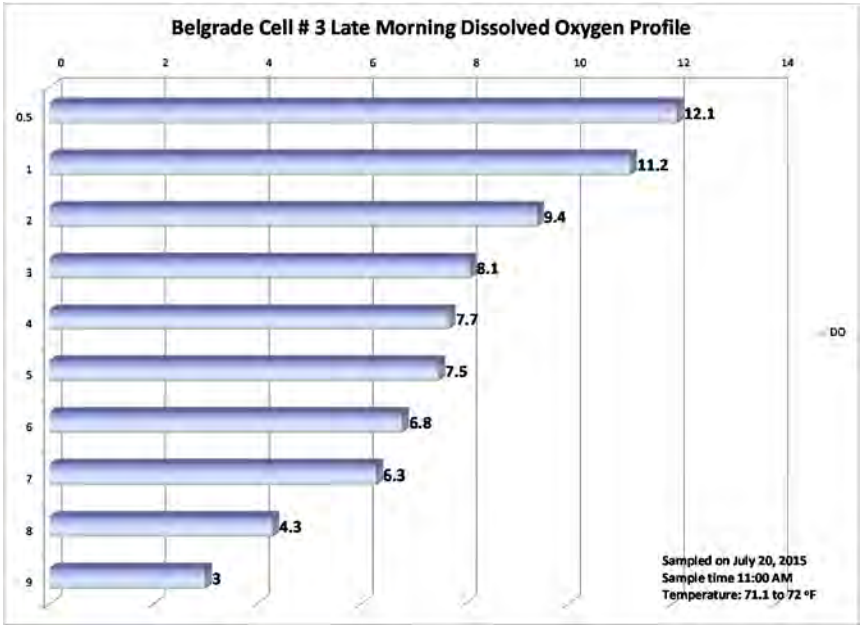


Figure 2 Dissolved Oxygen Levels Up During the Late Morning

Section 4 – Data Analysis Cont-

Aeration & Dissolved Oxygen

Under normal loading conditions a pond system will typically have much greater dissolved oxygen concentrations than are present in the Belgrade system. One would expect concentrations at least above 1 mg/l during the early morning hours. Air is useful for many things other than providing oxygen in a lagoon system. Aeration can strip CO_2 from the system to help control algae, aeration can help control odors. Aeration can aid in mixing and stopping short circuiting. Aeration can help strip out ammonia if the pH is high enough, and reduce ammonia if nitrifying bacteria are present. Aeration of course is also useful in removing BOD.

Turbulence, or water column agitation using aeration, is a solution for:

1) Reducing filamentous algae
2) Stifling duckweed growth
3) Lowering TSS by stripping off CO_2 for algae control
4) Raising pH by stripping off CO_2

Statistics run on the Belgrade 2012 to 2015 data set show no correlation between TSS and BOD_5. This is important because algae typically affect BOD permit limit test results. This lack of correlation in the Belgrade pond system is probably due to nitrification in the BOD_5 test bottle.

In a study of twenty-four (24) Colorado pond systems, it was discovered that sixty-seven percent (67%) of the BOD violations in this study were from algae overgrowth. (Richard & Bowman (1991))

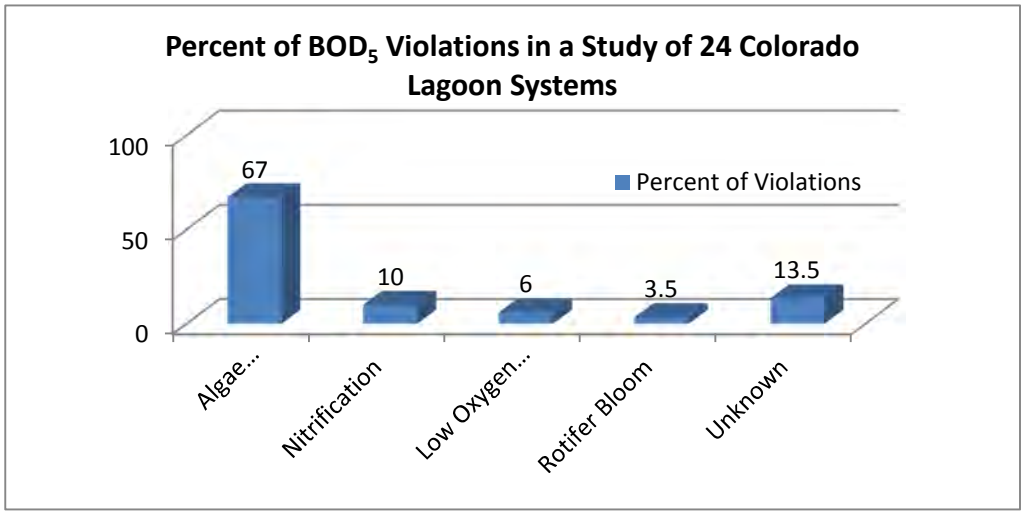


Figure 4. Colorado Research Showing Algae to be the Primary Cause of BOD Violations

Dead and decaying algae get into the BOD_5 test bottle and directly add to the BOD load but also the surviving algae consume oxygen under dark conditions in the BOD_5 test bottle and darkened BOD_5 incubator. This oxygen consuming metabolic process is known as respiration and happens at night in ponds and in incubators used in the BOD_5 test. The idea here is to have the pond's effluent free of algae to lower TN, BOD, and of course TSS. A TSS: BOD ratio over 2 indicates algae overgrowth or particulate matter causing high TSS. Less than 1.5 indicates nitrification and or short-circuiting.

Section 4 – Data Analysis Cont-

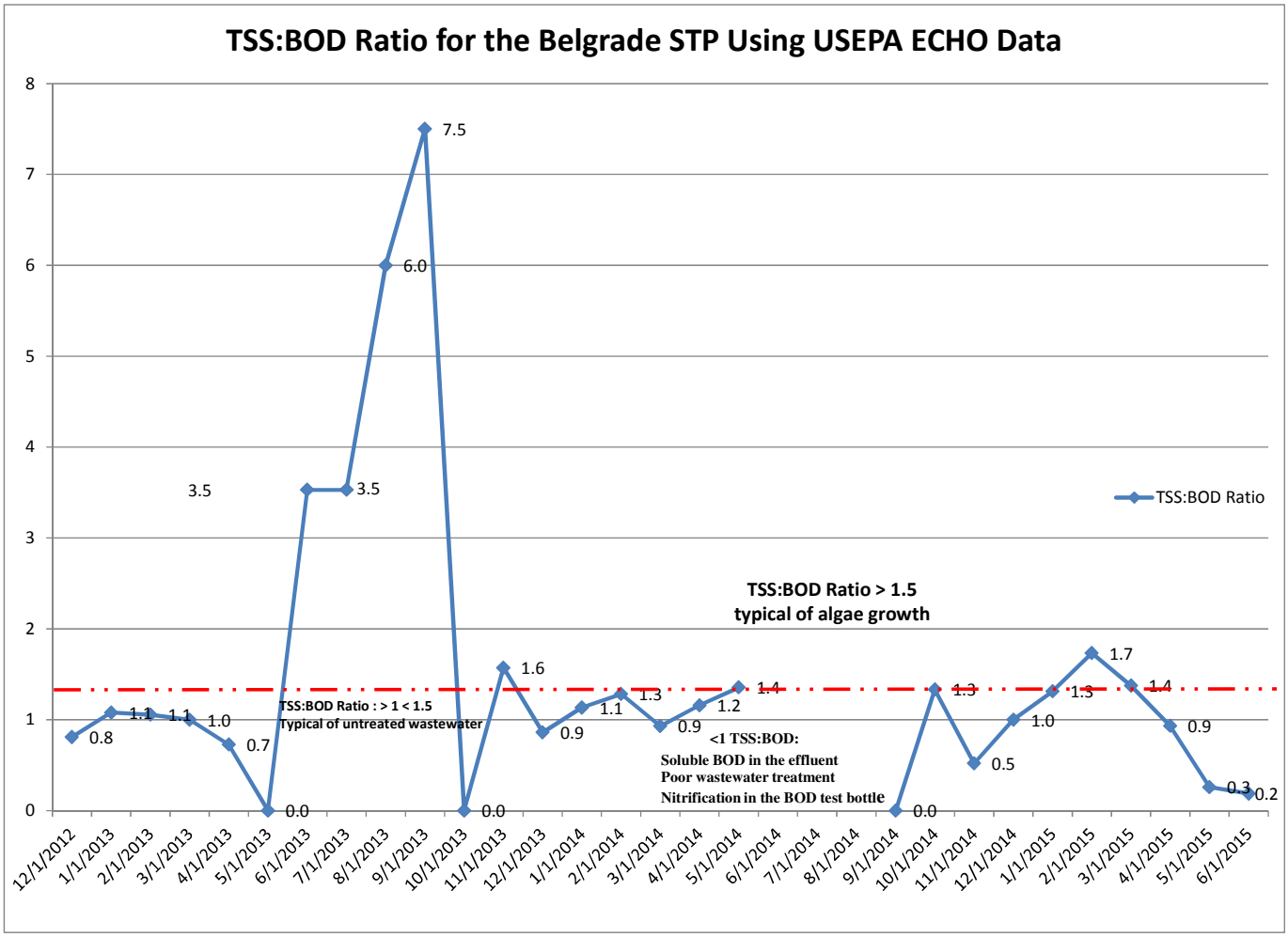


Figure 5. Belgrade TSS:BOD Ratio Showing the Probable Causes of its Effluent Results

High algae growth typically leads to elevated BOD_5 and Organic–N. It is widely accepted that an algae concentration of greater than 3.5 x 10^5/ml generally causes an effluent BOD_5 concentration of greater than 30 mg/L because of algae. Keep in mind that at night algae are consuming oxygen not producing it. This adds to oxygen demand taking it from the nutrient removal (TN reduction) pathways.

To confirm this fact, a filtered or soluble carbonaceous (SCBOD) test should be performed. This is a testing procedure where the effluent BOD_5 sample is run and the sample split, so the other half of the BOD sample can be passed through a TSS filter first before running the second BOD test. Comparing the BOD to the Filtered BOD (SBOD) will indicate algae's influence on the BOD test results and prove the need or not to separate algae as part of some tertiary treatment strategy.

Section 4 – Data Analysis Cont-

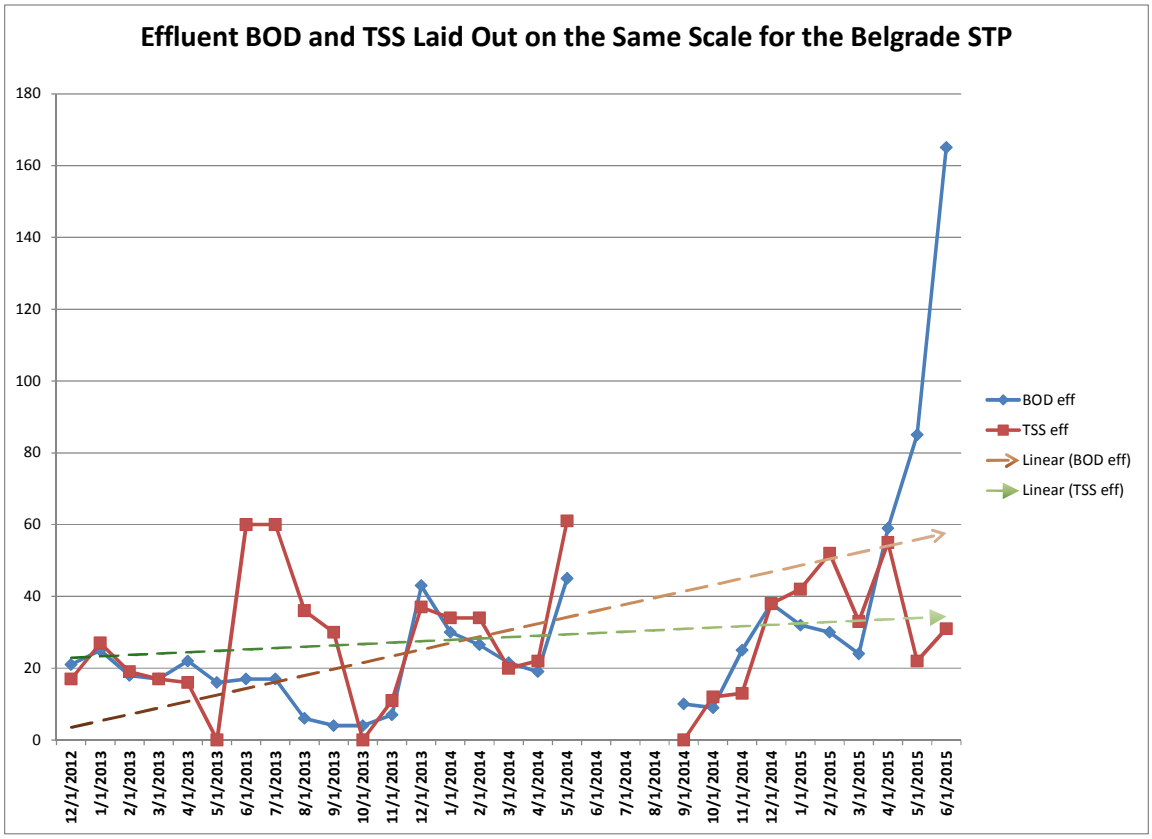


Figure 6. Effluent BOD and TSS on Same Scale Showing Possible Signs of Nitrification

There are signs that the system nitrifys. Effluent BOD greater than effluent TSS in a pond system is an indication of nitrification which can only occure in the presence of oxygen. The chart to the left shows that when ammonia concentrations are up, nitrate concentrations are down and visa versa. The pond system manufactures its own nitrate…a valuable oxygen resource if recirculated.

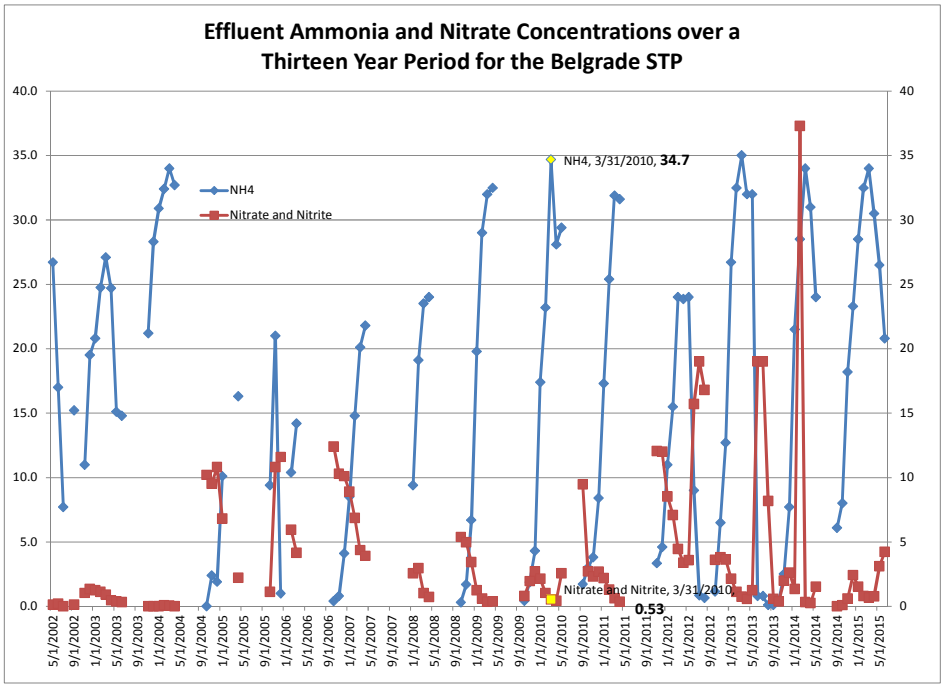


Figure 7 Nitrate vs Ammonia Concentrations at Belgrade

The Belgrade STP is capable of generating large amounts of nitrate, a component of TN. If recirculated this highly consumable nutrient can be removed in the primary treatment cell for TN reduction.

Section 4 – Data Analysis Cont-

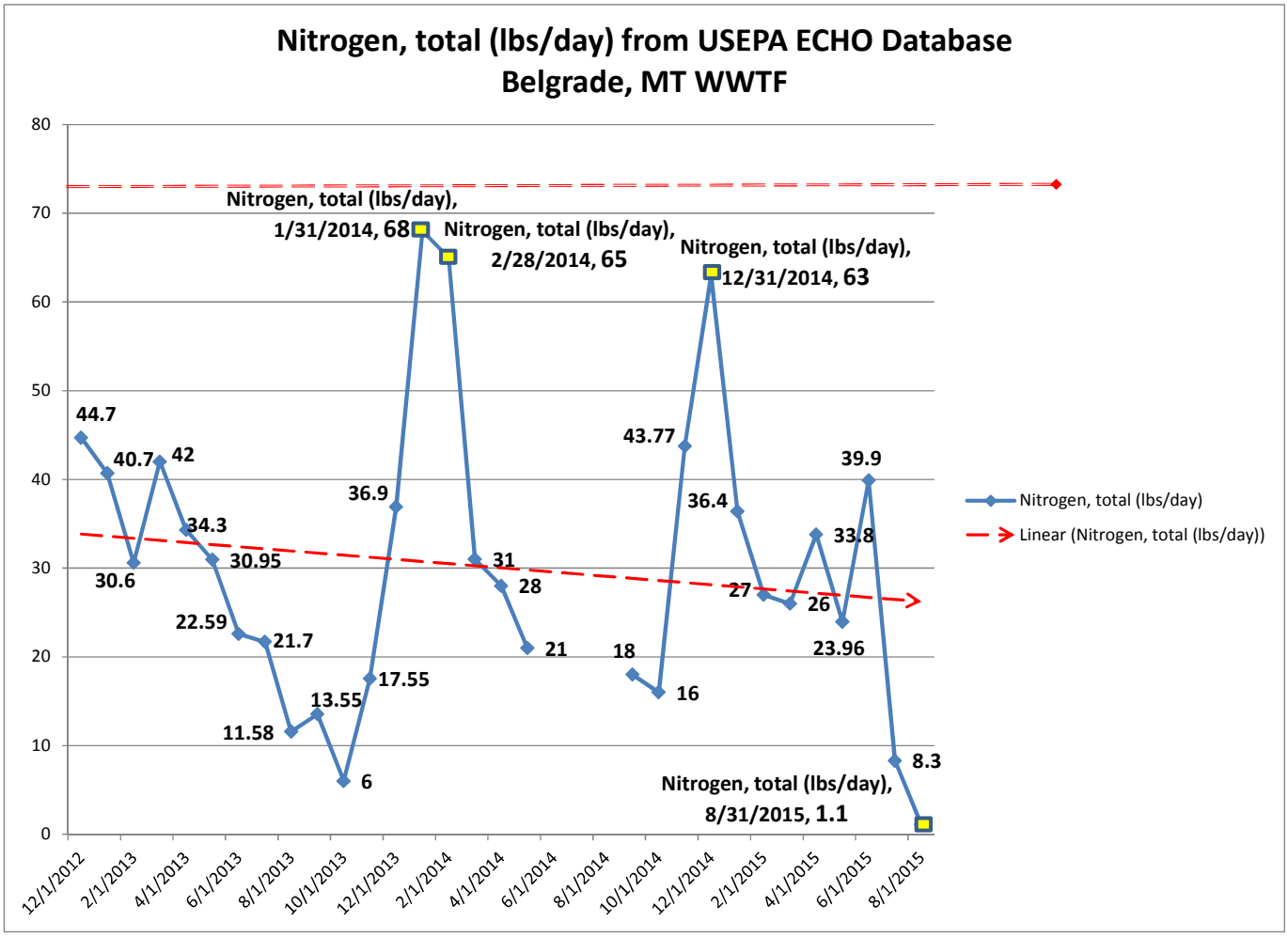


Figure 8 Effluent Total Nitrogen for the Belgrade Wastewater Pond System

Table 1: Effluent Limits

Outfall	Parameter Name	Units	Effluent Limitations
			Daily Maximum(1)(2)
Outfall 001-A	Total Nitrogen (as N)	lbs/day	72
Outfall 002-B	Total Nitrogen (as N)	lbs/day	72
Outfall 003-C	Total Nitrogen (as N)	lbs/day	74

Footnotes:
(1) See definition in Part V of permit.
(2) Report highest measured daily value for reporting period on Discharge Monitoring Report (DMR) form.

Section 4 – Data Analysis Cont-

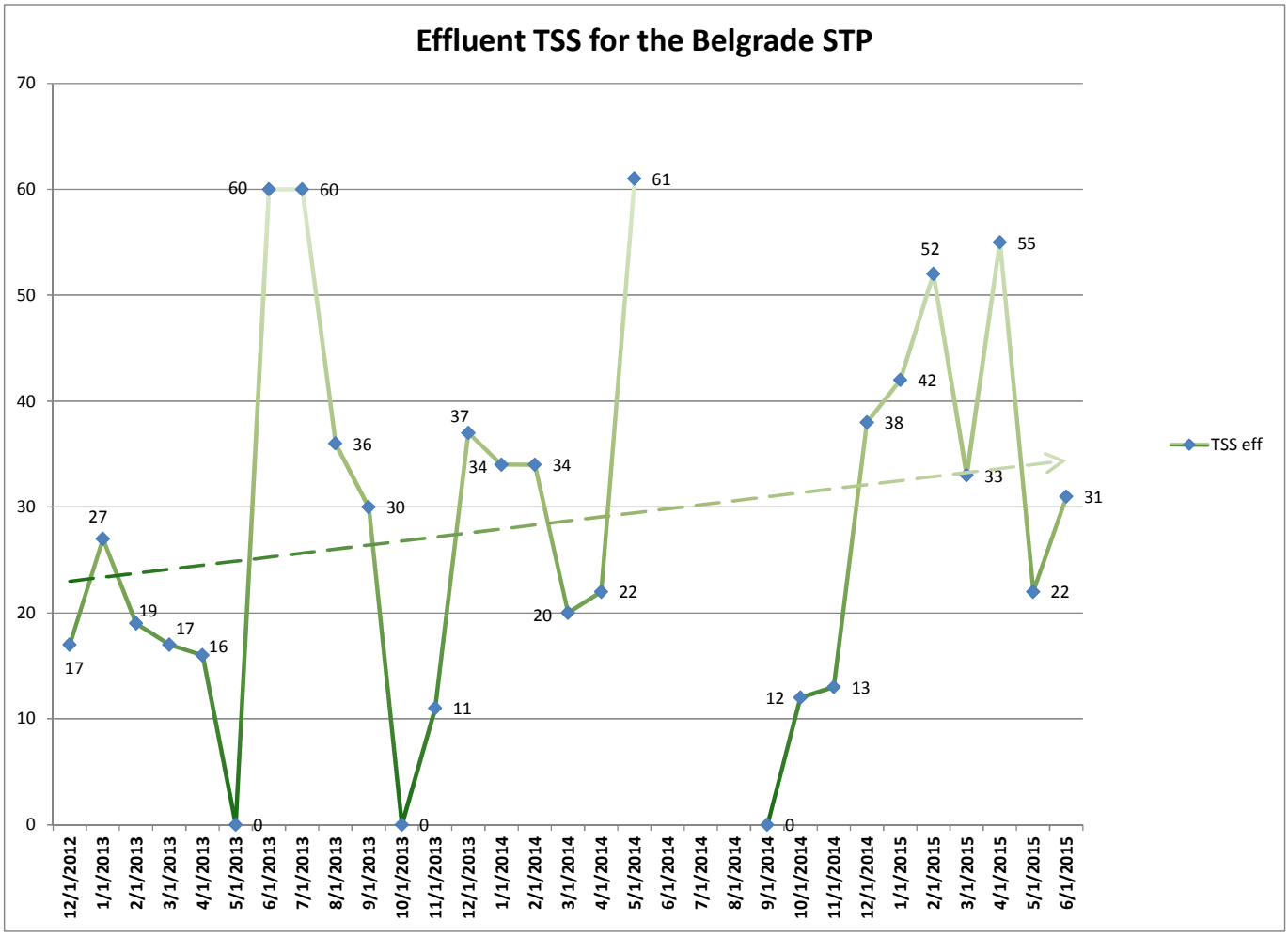


Figure 9. Belgrade Effluent TSS over 2 ½ years

Increasing TSS could be a sign of nutrient feedback from the sludge blanket feeding algae in Belgrade's water column. Also consider how the Belgrade effluent structure pulls water from the water column. Too close to the surface and the effluent will be filled with algae cells for TN problems. Too close to the bottom and it will pull up sludge and dead algae cells filled with nutrients. Effluent structures should be out one (1) foot past the toe of the dike and pull water from at least two (2) to three (3) feet down below the photic zone where algae thrive.

Section 4 – Data Analysis Cont-

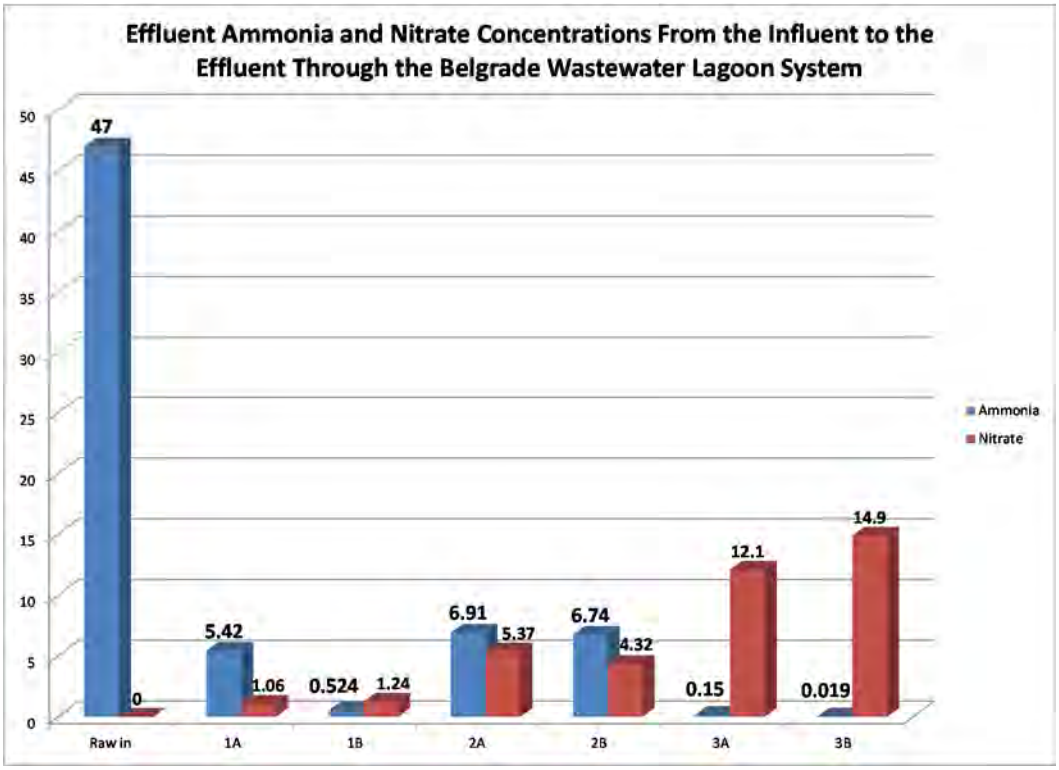


Figure 10. Nitrification is Evident by the Reduction of Ammonia and the Production of Nitrate through the System

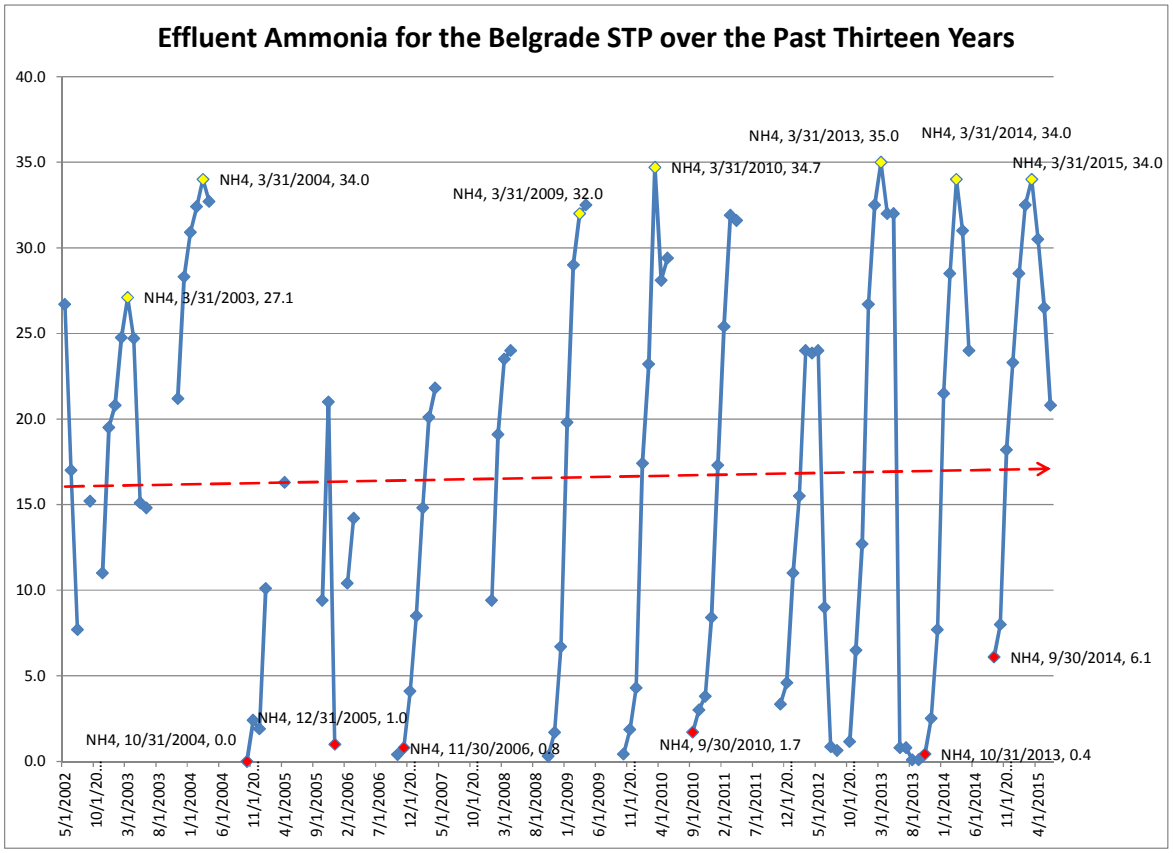


Figure 11 Effluent Ammonia Concentrations and their Timing are Fairly Predictable for the Belgrade System

Section 4 – Data Analysis – Cont -

There are no permit limits for effluent BOD_5. For the Belgrade system, BOD_5 can be used as a water quality indicator. Causes for high effluent BOD could include excessive loading, algae getting into the BOD_5 bottle, excessive sludge creating an O_2 demand or nitrification in the BOD_5 test bottle

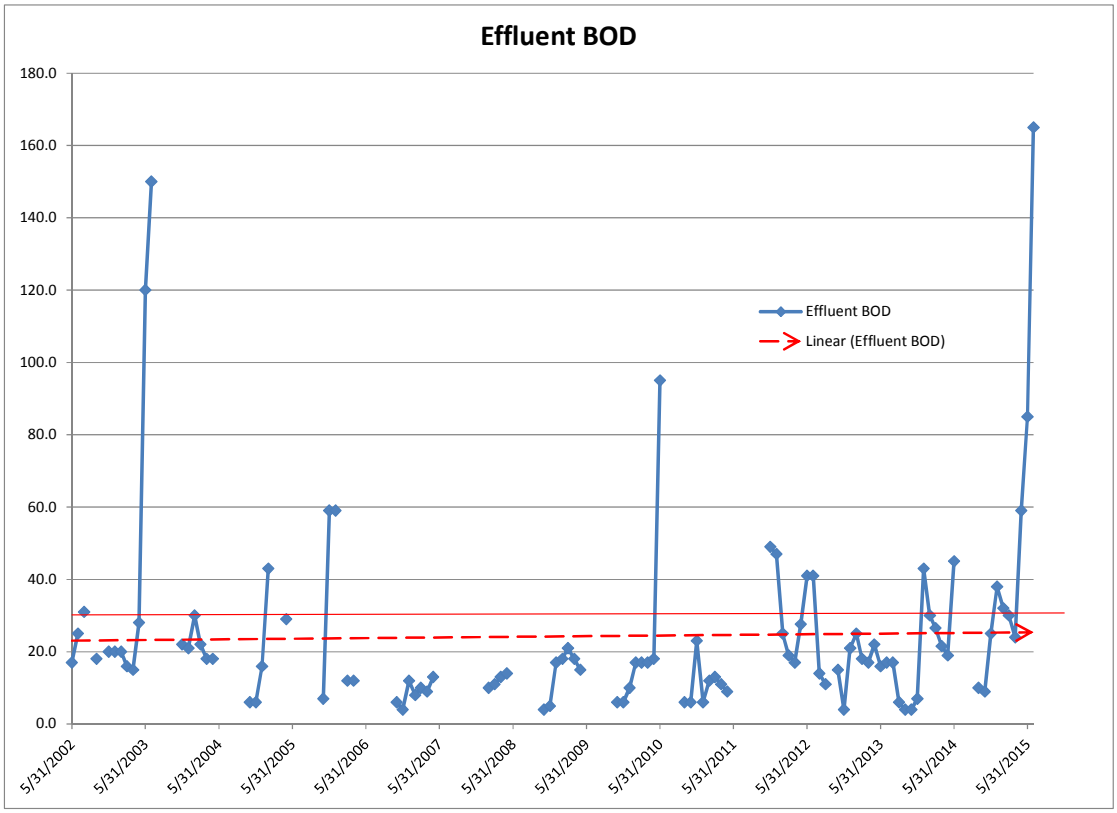


Figure 12. Effluent BOD for the Belgrade STP

When looked at over a shorter term the trend in effluent BOD is on the rise as can be seen in the chart below.

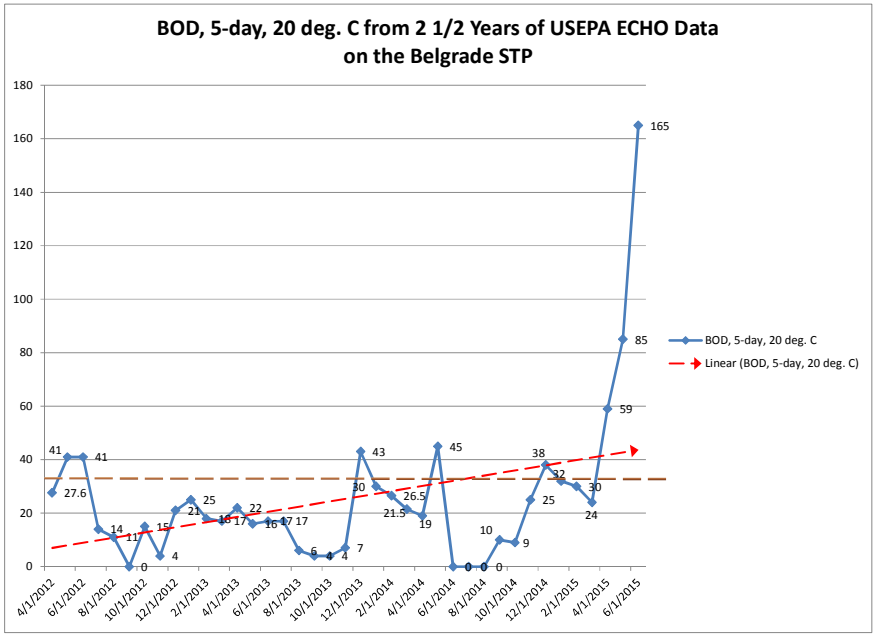


Figure 13 Effluent BOD Over the Last 2 1/2 years

Section 4 – Data Analysis – Cont. -

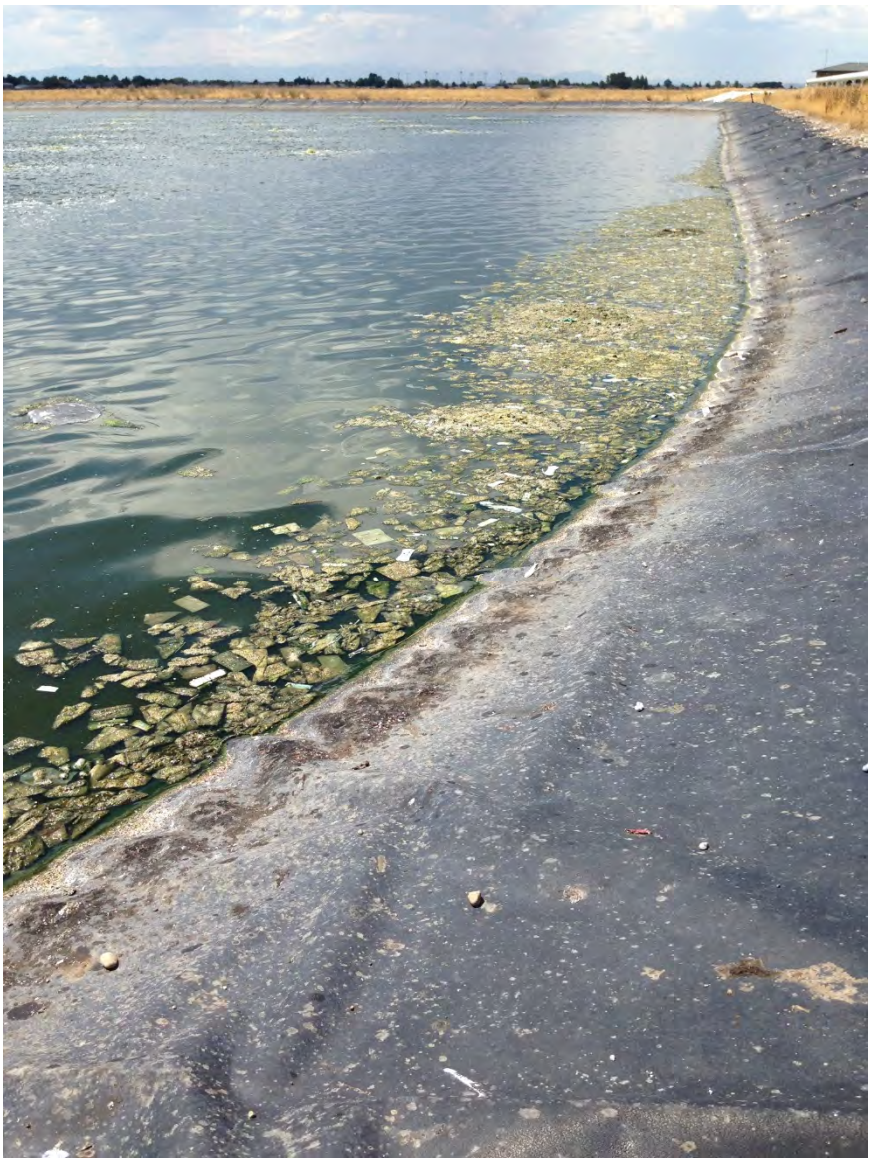


Figure 14 An Influent Headworks Structure with Screening Could lower the Influent BOD by 40% and Lower the Sludge Accumulation Rate and Cut Odors

Section 5 – Summary

In Summary, the Belgrade wastewater stabilization pond system is currently in compliance for effluent lbs. / day TN. Desludging the primary treatment cell is important for keeping this plant in long term sustained TN compliance. Aeration should be increased to compensate for the anoxic conditions that prevail throughout the evening and early morning hours. Increased aeration could be accomplished through recirculation and should be considered for the Belgrade system. A multiple level draw off structure can help the operator "select" the water quality he is to discharge and should also be considered for an upgrade to continue to keep this plant in compliance. Diagnostic BODs and a

Section 5 – Summary – Cont. -

A microscan can help tremendously at the Belgrade STP to pinpoint an exact cause and then a specific solution to potential TN problems.

Section 6 – Items for Immediate Action

- Maintain at least 2 mg/l of DO in Cell # 1 at all times. Belgrade operations personnel may elect to devote Cell # 2 to on/off air cycling leaving Cell # 1 to fully remove influent BOD load. A BOD below 20 mg/l will allow Cell # 2 to nitrify. More air to Cell # 1 would solve any potential odor problems in Cell # 1.
- Begin planning for Cell # 1 Sludge Removal

Section 6 – Conclusions

CONCLUSIONS

Because in all likelihood it is nitrification in the BOD_5 test bottle that is causing the large spikes in effluent BOD results, adding more air during the evening hours to Cell # 1 is one way to help get the ammonia down for TN reduction. For ammonia reduction through nitrification control, a minimum of two (2) mg/l is required. A combination of capital improvements like recirculation, adding or increasing aeration with desludging will probably keep the Belgrade STP system in long term sustained compliance for years to come. If these improvements fail to get keep the pounds of Total Nitrogen down, relatively inexpensive tertiary treatment strategies for ammonia, nitrate, and Organic-N removal are available.

Desludging and adding more air are probably the most important factors for continued long term Total Nitrogen compliance.

There is a ***where,* a *when,* and a *why*** to lagoon problem solving and optimization. Determining where treatment is or is not occurring is critically important to optimizing the Belgrade STP and keeping this system in compliance. Please see Diagnostic BODs in the Appendix and make a commitment to routinely performing these kinds of process control tests.

Thank you for the opportunity to serve the good people of Belgrade Montana.

Steve Harris
President
H&S Environmental, LLC

Appendix A

Sludge and Treatment Cell Volume Data

City of Belgrade, Montana					
Volume and retention Time calculator					
Using Trapezoidal Prism Calculations and a 3:1 slope					
Item	Units	**Cell 1**	**Cell 2**	**Cell 3**	**Total**
Bottom Length	feet	**1061.9**	**486.9**	**486.9**	
Bottom Width	feet	**446.9**	**486.9**	**486.9**	
Side Slopes	1 to	**3**	**3**	**3**	
Average Sludge Depth	feet	**1.55**	**0.11**	**0**	
As-Built Bottom Elevation	feet	**100.00**	**100.00**	**100.00**	
As-Built Top-of-Bank Elevation	feet	**150.85**	**140.00**	**140.00**	
Bottom Area	sq ft	474,563	237,072	237,072	
Top of Sludge Length	feet	1071.2	487.56	486.9	
Top of Sludge Width	feet	456.2	487.56	486.9	
Top of Sludge Area	sq ft	488,681	237,715	237,072	
Sludge Volume	cu ft	746,515	26,113	-	
Sludge Volume	gallons	**5,583,929**	**195,327**	**-**	**5,779,256**
Sludge Mass	dry tons				
Embankment Height	feet	50.85	50.00	50.00	
Freeboard Required	feet	**2**	**2**	**2**	
Useable Lagoon Depth	feet	7.30	11.00	11.00	
Top of Water Max Length	feet	1105.7	552.9	552.9	
Top of Water Max Width	feet	490.7	552.9	552.9	
Top of Water Max Area	sq ft	542,567	305,698	305,698	
Lagoon Volume	cu ft	3,712,525	2,985,235	2,985,235	
Usable Remaining Lagoon Volume after Sludge Volume of 1.55 ft	**gallons**	**27,769,686**	**22,329,559**	**22,329,559**	**72,428,803**
Current Retention Time at .568 MGD with sludge depth of 1.55 feet and Remaining Water Cap of 7.3 feet and average water depth at 8.85 feet in Primary Cell	**days**	**48.9 days**	**39 days**	**39 days**	**127.5 days**
These are rough estimates as water levels vary and flow to each cell varies with evaporation					

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Belgrade Wastewater Master Plan
Sludge Volume Verification
TD&H Job No. B16-048

Lagoon #1

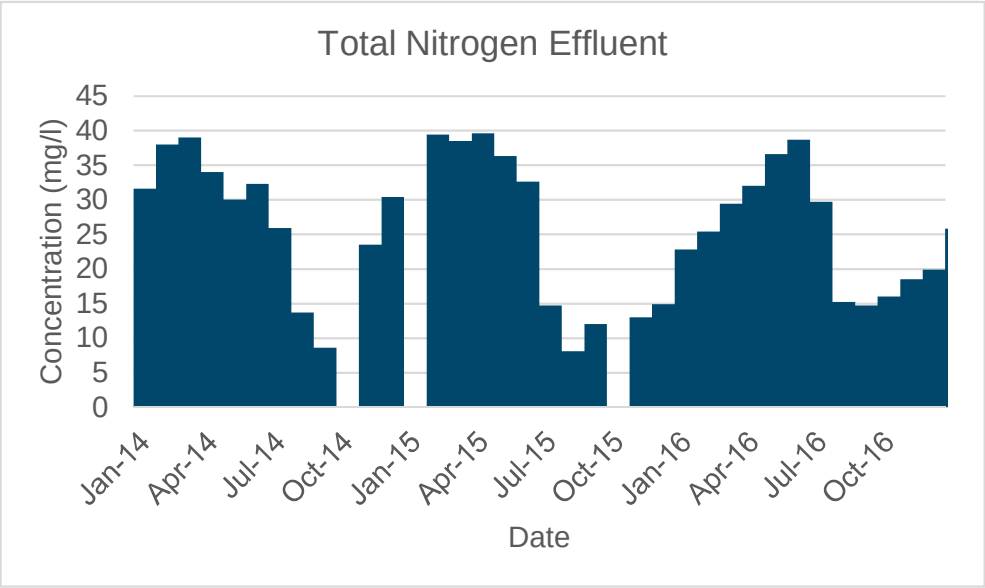
depth=	1.55	ft
bottom length	474	ft
bottom width	470	ft
bottom area	222780	sf
side slope horizontal	4	:1
top length	486.4	ft
top width	482.4	ft
top area	234639.36	sf
volume	354500.004	cf
	2,652,014.53	gals

Lagoon #1 and #2 Combined
(conservatively assuming sludge volume in Lagoon #1 equals sludge volume in Lagoon #2)

Total Volume= 5,304,029.06 gallons

EXISTING AGRONOMIC RATE CALCULATIONS

Belgrade Wastewater Master Plan
Effluent Total Nitrogen Concetrations



Month	TN Effluent Concentraion	Month	TN Effluent Concentraion
	(mg/l)		(mg/l)
Jan-14	31.6	Oct-15	
Feb-14	38	Nov-15	13
Mar-14	39	Dec-15	14.9
Apr-14	34	Jan-16	22.8
May-14	30	Feb-16	25.4
Jun-14	32.3	Mar-16	29.4
Jul-14	25.9	Apr-16	32
Aug-14	13.7	May-16	36.6
Sep-14	8.6	Jun-16	38.7
Oct-14		Jul-16	29.7
Nov-14	23.5	Aug-16	15.2
Dec-14	30.4	Sep-16	14.7
Jan-15		Oct-16	16
Feb-15	39.4	Nov-16	18.5
Mar-15	38.5	Dec-16	19.9
Apr-15	39.6	Jan-17	25.8
May-15	36.3	Feb-17	28.7
Jun-15	32.6	Mar-17	31.8
Jul-15	14.7	Apr-17	32.9
Aug-15	8.1	May-17	33

Belgrade Wastewater Treatment
Treatment and Disposal
Agronmic Rates
TD&H Job No. B16-048

Designed by: NMR 04.21.2017

Irrigation System Design Calculations

DENOTES USER INPUT

See attached references for data, tables, charts, etc.

Project Specific Design Criteria:

BOD_5 Influent Concentration = **408** mg/l
BOD_5 Effluent Concentration = **33** mg/l

DEQ-2 Design Criteria:

Circular DEQ-2, Table 93-1

Disposal Method = **Controlled Discharge**
Primary Cells Detention Time = **20** days
Overall System Detention Time = **110** days (Minimum)

Precipitation and Evaporation Data:

Western Regional Climate Center
Lake Evaporation estimated at 70% of pan evaporation.

Wettest-Year-in-10 Precipitation	
Month	Precipitation Inches
January	0.07
February	0.27
March	0.71
April	1.60
May	1.73
June	2.99
July	2.41
August	1.01
September	3.17
October	1.57
November	1.64
December	1.10

ANNUAL 18.27 inches/year
PEAK YEAR (1969) 20.04 inches
10-YR FACTOR = 1.0969

Lake Evaporation			
Month	Pan Evap. Inches	Lake Evap. Factor	Lake Evap. Inches
January	0.00	0.7	0.00
February	0.00	0.7	0.00
March	0.00	0.7	0.00
April	3.34	0.7	2.34
May	5.58	0.7	3.91
June	6.03	0.7	4.22
July	8.34	0.7	5.84
August	7.17	0.7	5.02
September	4.57	0.7	3.20
October	2.62	0.7	1.83
November	0.00	0.7	0.00
December	0.00	0.7	0.00

ANNUAL **26.355** inches/year

Assumptions:

The irrigation season includes half of May And September (16 days each) and all of June, July and August.

Annual Hydraulic Loading Rate:

Circular DEQ-2, Section 121.113.1

The design maximum irrigation application rates, L_H, must be calculated for each month using hydraulic loading rates based on soil permeability and nitrogen loading. The limiting factor, permeability or nutrient uptake, will be used for design.

Soil Permeability Calculations:

Circular DEQ-2, Section 121.113.11

$$L_p = \frac{ETc - P + P_w}{SE}$$

L_p = inches (hydraulic loading rate)
ETc = inches (crop evapotranspiration)
P = inches (precipitation)
P_w = inches (percolation rate)
SE = fraction (distribution system efficiency, 0.70 to 0.85 for sprinklers)

Percolation Rate:
EPA Process Design Manual - Land Treatment of Municipal Wastewater (EPA 625/1-81-013)
Web Soil Survey - Saturated Hydraulic Conductivity (Ksat)
DEQ-4 Table 2.1-1 Percolation Rates

Method 1:

The design percolation rate is 4 to 10 percent of the limiting permeability or hydraulic conductivity for the most restrictive soil layer.

Soil Type =	**Attewan Clay Loam**		(Web Soil Survey)
	Beaverell Loam		(Web Soil Survey)
	Beavwan Loam		(Web Soil Survey)
	Beaverell Cobbly Loam		(Web Soil Survey)
	Beaverell-Beavwan Complex		(Web Soil Survey)
Percolation Rate =	**28.5**	min/inch	(DEQ-4 T. 2.1-1, average for percolation rates for loamy sand)
Percolation Rate =	0.035087719	inches/min	
Percolation Rate =	2.105263158	inches/hr	
Design Percolation Rate =	0.084210526	inches/hr	(4% of Percolation Rate)

Method 2:

Soil Type =	**Attewan Clay Loam**		(Web Soil Survey)
	Beaverell Loam		(Web Soil Survey)
	Beavwan Loam		(Web Soil Survey)
	Beaverell Cobbly Loam		(Web Soil Survey)
	Beaverell-Beavwan Complex		(Web Soil Survey)
K_{sat} =	**64.1513**	µm/sec	(Beaverell loam, Beaverell Cobbly Loam, Beaverell-Beavwan Complex, 91.5% of irrigation area.)
Design Percolation Rate =	9.09	inches/hr	

Choose the most conservative Design Percolation Rate:

P_w =	0.084210526	inches/hr	(Design Percolation Rate)

Initial Monthly Percolation:
Use 3:1 drying: wetting ratio for each irrigated month.
The irrigation time is equal to 1/4 of the irrigated days per month.
The Design Percolation Rate is applied to the irrigation time per month.

Month	Irrigated Days	Initial Irrigation Time Hours	P_w Inches
May	**15**	90	7.58
June	**30**	180	15.16
July	**31**	186	15.66
August	**31**	186	15.66
September	**15**	90	7.58
October	**0**	0	0.00

Crop Evapotranspiration Rate:
Figure 4.1 Irrigation Climatic Areas of Montana, August 1986

Climatic Area =	**4**	**Moderately Low Consumptive Use**
Crop =	**Alfalfa**	

Estimated Irrigation Requirements
Based on Belgrade's 2004 Design Report

Month	Total Consumptive Use (ETc) Inches
May	**2.50**
June	**5.10**
July	**7.10**
August	**6.60**
September	**3.40**
October	**0.00**

Permeability Water Balance:

$$L_p = \frac{ETc - P + P_w}{SE}$$

Month	ETc Inches	P Inches	P_w Inches	SE	L_p Inches
May	2.50	1.73	7.58	0.85	9.82
June	5.10	2.99	15.16	0.85	20.32
July	7.10	2.41	15.66	0.85	23.94
August	6.60	1.01	15.66	0.85	25.00
September	3.40	3.17	7.58	0.85	9.19
October	0.00	1.57	0.00	0.85	0.00
Annual	24.70	12.88	61.64		88.27

Nitrogen Calculations:
Circular DEQ-2, Section 121.113.12

$$L_N = \frac{U * C}{C_N(1-f)}$$

L_N = inches (Hydraulic Loading)
U = LB/acre-month (crop uptake as a function of yield)
C = 4.41 (conversion constant)
C_N = mg/L (applied total nitrogen concentration)
f = Nitrogen Loss factor

Crop Nutrient Uptake:
Ranges from 225 to 540 kg/ha-yr
U avg = 382.5 kg/ha-yr
U avg = 342.1 LB/acre-yr (2.21 LB/kg and 0.4047 ha/acre)

Based on NRCS extension service research, assume:
U avg = **183.2** LB/acre-yr (assume occurs during the irrigated days)
(Based on MM 2004 design)

Nitrogen Loss Factor:
per DEQ-2 Section 112.113.12:
Shall not exceed 0.2 for secondary treatment effluent.
Shall not exceed 0.1 for effluent from facilities utilizing nutrient removal methods.
f = **0.2**

Total Nitrogen Concentration:
Measured Total Nitrogen Concentrations

Month	Total Nitrogen Concentration (mg/l)
Apr-13	35.57
May-13	41.24
Jun-13	27
Jul-13	21.7
Aug-13	13.2
Sep-13	5.39
Oct-13	3.28
Apr-14	34
May-14	30
Jun-14	32.3
Jul-14	25.9
Aug-14	13.7
Sep-14	8.6
Oct-14	10.29
Mar-15	36.3
Apr-15	39.6
May-15	36.3
Jun-15	32.6
Jul-15	14.7
Aug-15	8.1
Sep-15	12
Oct-15	14.67
May-16	36.6
Jun-16	38.7
Jul-16	29.7
Aug-16	15.2
Sep-16	14.7
Oct-16	16

Nitrogen Water Balance:

Annual Etc= 24.70 inches

Month	Total Consumptive Use (ETc) Inches	U LB/acre	L_N Inches
Apr-13	0.00	0.00	0.00
May-13	2.50	18.54	2.48
Jun-13	5.10	37.83	7.72
Jul-13	7.10	52.66	13.38
Aug-13	6.60	48.95	20.44
Sep-13	3.40	25.22	25.79
Oct-13	0.00	0.00	0.00
Apr-14	0.00	0.00	0.00
May-14	2.50	18.54	3.41
Jun-14	5.10	37.83	6.46
Jul-14	7.10	52.66	11.21
Aug-14	6.60	48.95	19.70
Sep-14	3.40	25.22	16.16
Oct-14	0.00	0.00	0.00
Mar-15	0.00	0.00	0.00
Apr-15	0.00	0.00	0.00
May-15	2.50	18.54	2.82
Jun-15	5.10	37.83	6.40
Jul-15	7.10	52.66	19.75
Aug-15	6.60	48.95	33.31
Sep-15	3.40	25.22	11.58
Oct-15	0.00	0.00	0.00
May-16	2.50	18.54	2.79
Jun-16	5.10	37.83	5.39
Jul-16	7.10	52.66	9.77
Aug-16	6.60	48.95	17.75
Sep-16	3.40	25.22	9.46
Oct-16	0.00	0.00	0.00

Limiting Annual Hydraulic Loading Rate:

The smallest Hydraulic Loading Rate per month controls.

Month	L_P Inches	L_N Inches	L_H Inches	Limiting Process
Apr-13	0.00	0.00	**0.00**	Nitrogen
May-13	9.82	2.48	**2.48**	Nitrogen
Jun-13	20.32	7.72	**7.72**	Nitrogen
Jul-13	23.94	13.38	**13.38**	Nitrogen
Aug-13	25.00	20.44	**20.44**	Nitrogen
Sep-13	9.19	25.79	**9.19**	Permeability
Oct-13	0.00	0.00	**0.00**	Nitrogen
Apr-14	0.00	0.00	**0.00**	Nitrogen
May-14	9.82	3.41	**3.41**	Nitrogen
Jun-14	20.32	6.46	**6.46**	Nitrogen
Jul-14	23.94	11.21	**11.21**	Nitrogen
Aug-14	25.00	19.70	**19.70**	Nitrogen
Sep-14	9.19	16.16	**9.19**	Permeability
Oct-14	0.00	0.00	**0.00**	Nitrogen
Mar-15	0.00	0.00	**0.00**	Nitrogen
Apr-15	0.00	0.00	**0.00**	Nitrogen
May-15	9.82	2.82	**2.82**	Nitrogen
Jun-15	20.32	6.40	**6.40**	Nitrogen
Jul-15	23.94	19.75	**19.75**	Nitrogen
Aug-15	25.00	33.31	**25.00**	Permeability
Sep-15	9.19	11.58	**9.19**	Permeability
Oct-15	0.00	0.00	**0.00**	Nitrogen
May-16	9.82	2.79	**2.79**	Nitrogen
Jun-16	20.32	5.39	**5.39**	Nitrogen
Jul-16	23.94	9.77	**9.77**	Nitrogen
Aug-16	25.00	17.75	**17.75**	Nitrogen
Sep-16	9.19	9.46	**9.19**	Permeability
Oct-16	0.00	0.00	**0.00**	Nitrogen

Existing versus Agronmic Loading

Application Area= 117 acers
5,096,520 SF

Month	Irrigation Days	Agronimic Application Rate (inches)	Argonomic Flow Rate (gpd)	Existing Irrigation Flow Rate (gpd)
Jan-13	0	0.00	0	0
Feb-13	0	0.00	0	0
Mar-13	0	0.00	0	0
Apr-13	0	0.00	0	181,593
May-13	15	2.48	525,000	684,061
Jun-13	30	7.72	817,927	471,652
Jul-13	31	13.38	1,371,091	682,162
Aug-13	31	20.44	2,095,258	349,668
Sep-13	15	9.19	1,945,962	693,078
Oct-13	0	0.00	0	514,780
Nov-13	0	0.00	0	0
Dec-13	0	0.00	0	0
Jan-14	0	0.00	0	0
Feb-14	0	0.00	0	0
Mar-14	0	0.00	0	0
Apr-14	0	0.00	0	164,480
May-14	15	3.41	721,700	518,750
Jun-14	30	6.46	683,716	248,579
Jul-14	31	11.21	1,148,752	875,540
Aug-14	31	19.70	2,018,789	1,010,241
Sep-14	15	9.19	1,945,962	185,105
Oct-14	0	0.00	0	597,221
Nov-14	0	0.00	0	0
Dec-14	0	0.00	0	0
Jan-15	0	0.00	0	0
Feb-15	0	0.00	0	0
Mar-15	0	0.00	0	103,116
Apr-15	0	0.00	0	638,851
May-15	15	2.82	596,446	638,033
Jun-15	30	6.40	677,424	419,971
Jul-15	31	19.75	2,023,991	969,293
Aug-15	31	25.00	2,562,684	648,546
Sep-15	15	9.19	1,945,962	375,431
Oct-15	0	0.00	0	673,544
Nov-15	0	0.00	0	0
Dec-15	0	0.00	0	0
Jan-16	0	0.00	0	0
Feb-16	0	0.00	0	0
Mar-16	0	0.00	0	0
Apr-16	0	0.00	0	0
May-16	15	2.79	591,557	458,806
Jun-16	30	5.39	570,647	340,227
Jul-16	31	9.77	1,001,773	1,176,625
Aug-16	31	17.75	1,819,566	789,756
Sep-16	15	9.19	1,945,962	512,487
Oct-16	0	0.00	0	454,224
Nov-16	0	0.00	0	0
Dec-16	0	0.00	0	0

APPENDIX 5

WATER USAGE CALCULATIONS

Belgrade Wastewater Master Plan
Average Water Usage Calculations

2013

Estimated Population= 7693 persons

2013 Monthly Per Capita Water Usage			
Month	**Water Usage (gal)**	**Average Daily Usage (gpd)**	**Average Per Capita Usage (gpcd)**
January	21,844,000	704,645	91.60
February	15,717,000	561,321	72.97
March	16,525,000	533,065	69.29
April	16,432,000	547,733	71.20
May	36,797,000	1,187,000	154.30
June	35,883,000	1,196,100	155.48
July	73,123,000	2,358,806	306.62
August	88,624,000	2,858,839	371.62
September	47,596,000	1,586,533	206.23
October	19,959,000	643,839	83.69
November	15,568,000	518,933	67.46
December	17,951,000	579,065	75.27

2014

Estimated Population= 7798 persons

2014 Monthly Per Capita Water Usage			
Month	**Water Usage (gal)**	**Average Daily Usage (gpd)**	**Average Per Capita Usage (gpcd)**
January	18,212,000	587,484	75.34
February	16,493,000	589,036	75.54
March	15,571,000	502,290	64.41
April	19,679,000	655,967	84.12
May	23,720,000	765,161	98.12
June	44,459,000	1,481,967	190.04
July	70,037,000	2,259,258	289.72
August	63,868,000	2,060,258	264.20
September	34,135,000	1,137,833	145.91
October	22,164,000	714,968	91.69
November	15,854,000	528,467	67.77
December	20,068,000	647,355	83.02

2015

Estimated Population= 8071 persons

2015 Monthly Per Capita Water Usage			
Month	**Water Usage (gal)**	**Average Daily Usage (gpd)**	**Average Per Capita Usage (gpcd)**
January	16,287,000	525,387	65.10
February	16,678,000	595,643	73.80
March	17,022,000	549,097	68.03
April	20,457,000	681,900	84.49
May	21,312,000	687,484	85.18
June	47,305,000	1,576,833	195.37
July	77,172,000	2,489,419	308.44
August	60,525,000	1,952,419	241.91
September	49,512,000	1,650,400	204.49
October	26,623,000	858,806	106.41
November	16,491,000	549,700	68.11
December	21,450,000	691,935	85.73

DEQ MEETING NOTES

1800 River Drive North
Great Falls, MT 59401

406.761.3010
tdhengineering.com

MEETING NOTES

Date:	02.08.2017	**Time:**	10:00-11:30am
Present:	Wade Deboo, TD&H Nicole Rediske, TD&H Chris Boe, DEQ	Steve Klotz, City of Belgrade Paul LaVigne, DEQ 2 others from DEQ	
Subject:	Groundwater Discharge Permit	**TDH Job No.:**	B16-084

DEQ Contact Person:
Chris Boe: 406-444-6752
CBOE@mt.gov

Received from DEQ:

- Water Quality Permit Application, Nondegredation Authorization, and Annual Permit Fees Summary
- Domestic Wastewater- Permit Application
- Compliance Evaluation Inspection violation letter, dated Feb 3, 2017
- General Information, Form 1
- Current Belgrade Permit Fact Sheet

All received items were scanned in and saved,
J:\2016\B16-048 Belgrade Master Plan\DOCUMENTS\MEETINGS\2017.02.08 DEQ Meeting

Permit Renewal Timeline/Process:

- Current permit expires November 30, 2017
- Submit letter to DEQ six (6) months prior to permit expiration (end of April) stating we are working on the permit renewal
- DEQ has a lot of new permit applications, may take time to review Belgrade's application
- Complete permit application to DEQ by Fall 2017
    - Once the permit application has been received, the current permit expiration date will likely be extended until the new permit is finalized.
    - DEQ seemed flexible and willing to work with us on timing
    - Application fees: $2,500 per outfall ($7,500 total)
      Will be more if nondegredation is required

Monitoring Wells:

- DEQ likes monitoring well network, would like to retain
- All samples have been below 10 mg/l (human health standard)
- DEQ would like figure showing groundwater contours and measured concentration profiles in Fact Sheet.

    - Expected to be helpful during public comment period
    - West Yellowstone is a good example
- DEQ requested all inactive monitoring wells be checked on to ensure they are still viable
    - Static water level in each well
- Update fact sheet with spatial information about well locations (lat/longs)

Effluent Limits
- Likely to retain current effluent limits
    - Total Nitrogen loading on the three beds
    - Able to request change if wanted

IP Beds
- DEQ has expected the effluent to be evenly distributed among the three outfalls.

Irrigation System
- DEQ would like to retain, even expand irrigation system if possible
- Double check agronomic rates
- The City indicated the airport has used extra fertilizer around the irrigation system
    - DEQ suggested contacting airport about the amount of fertilizer used.

Surface Water
- May need to look at projected impacts to surface water
    - Internal DEQ discussion as to whether or not this is required
- Likely to get some public comment
- Focus on nitrate, don't worry so much about phosphorous

Permit Renewal
- Focus on current system, don't take into account any expected modifications
- May require new SOPs
- Current mixing zone are applicable to new permit
- The current system is considered an "existing source"
    - Uses human health standards rather than nondegradation. That is not expected to change (10 mg/l at the end of mixing zone)
- City express desire to change the current permit as little as possible.

Future Modifications
- If TN load increases, permit standards will likely move from human health standard to nondegradtaion standard
    - Would decrease acceptable TN concentrations at the end of mixing zone
- When design flow increases, enhance treatment to decrease TN concentration to keep from moving to nondegredation standard
- No other new parameters were suggested for monitoring in the next permit cycle

AFTER DEQ MEETING, WE SAT DOWN WITH STEVE KLOTZ

- Steve will be in town for Rural Water if we have any questions or would like to sit down with him
- E-mail Steve a list of anything else we have questions on or need

- The City does not need to be directly involved in discussions with FAA or airport. Would like to simply be kept informed of any outcomes.
- Steve confirmed they do not have any maintenance TV inspections of the collection system.
- DMR data does not come directly from the SCADA system. They use the flow reading from the manual valves downstream of the mag meters for DMR data.
- The City is mapping the collection system with GIS. Currently ongoing. Likely to be complete soon
- Has run time records for the small blower. Can e-mail and ask him to send them over.
- Wade mentioned lagoon flow discrepancies. Steve is willing to have the mag meters checked. We are to follow up and organize.

DEQ CORRESPONDENCE GROUNDWATER DISCHARGE PERMIT

Nicole Rediske - RE: Belgrade Groundwater Discharge Permit Renewal Application

From: "Boe, Chris" <CBoe@mt.gov>
To: Nicole Rediske <Nicole.Rediske@tdhengineering.com>
Date: 4/11/2017 8:20 AM
Subject: RE: Belgrade Groundwater Discharge Permit Renewal Application
Cc: "steve@cityofbelgrade.net" <steve@cityofbelgrade.net>
Attachments: 2016__MTX000116_1year_reminder.docx

Hi Nicole-

Thank you for your letter. I believe our earlier meeting was very beneficial.

Please note that the permit expires on November 30, 2017. The application needs to be received before this date in order to provide DEQ time to review. Application fees are due on June 3, 2017. This is also the date in which an application is due, however we can work with you on the application due date if flexibility is needed.

In your letter you discussed loading "limits" in determining new/increase sources. I think we are on the same page, but just in case, please note that Belgrade's current Nondegradation determination is based on their currently approved wastewater design load (treatment and flow capacities). Currently there are no official limits in the permit to maintain this, rather if and when Belgrade decides to modify their system, DEQ will undergo another Nondegradation determination to confirm if the TN loading design rates are (or are not) increasing.

The water quality based effluent limits of Table 1 in the permit may increase or decrease depending on ambient nitrates of the aquifer. I anticipate that current or future violations of these numeric effluent limits will not have an impact on future Nondegradation determinations.

As discussed in our meeting, a look at cumulative effects and reasonable potential impacts on downgradient ground water and surface water quality could very much be needed. These are normally completed in use of conservative projections. I would however highly recommend taking advantage of the existing monitoring well network and ground water quality data to determine the site-specific fate and transport of the nutrients being discharged from this project. We can discuss this more in detail over the phone if you wish.

We look forward to working with you on Belgrade's master plan and the upcoming permit application. Please let me know if you have any questions or would like to set up another meeting.

Thanks once again for your preapplication efforts.

Regards-

Chris Boe
Environmental Science Specialist
Lead Worker - Ground Water Discharge Permitting Program

Montana Department of Environmental Quality - Water Protection Bureau

Phone: 406-444-6752
Fax: 406-444-1374
CBoe@mt.gov

1520 E. 6th Avenue
PO Box 200901
Helena, MT 59620-0901

MGWPCS program and permit info:
http://deq.mt.gov/Water/WQINFO/mgwpcs
MGWPCS application forms and fee info:
http://deq.mt.gov/Water/WPB/wpbforms

-

From: Nicole Rediske [Nicole.Rediske@tdhengineering.com]
Sent: Friday, April 07, 2017 1:28 PM
To: Boe, Chris
Cc: steve@cityofbelgrade.net
Subject: Belgrade Groundwater Discharge Permit Renewal Application

Good Afternoon Chis,

Please find the attached letter regarding the City of Belgrade's discharge permit renewal application.

Please do not hesitate to contact me with any questions or concerns.

Thank you,

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

DESIGN EFFLUENT CONCENTRATION CALCULATIONS

Belgrade Wastewater Master Plan
Design Effluent TN Concentrations
Month-By-Month Water Balance

Month	Days	IN		OUT								Δ Storage	Cumulative Storage
		Design Flow		IP Bed A		IP Bed B		IP Bed C		Land Application			
		(gpd)	(gal)	(gal)	(gpd)	(gal)	(gpd)	(gal)	(gpd)	(in)	(gal)	(gal)	(gal)
January	31	1,670,000	51,770,000	16,165,857	521,479	16,165,857	521,479	16,165,857	521,479			3,272,428	11,419,713
February	28	1,670,000	46,760,000	16,165,857	577,352	16,165,857	577,352	16,165,857	577,352			-1,737,572	9,682,142
March	31	1,670,000	51,770,000	16,165,857	521,479	16,165,857	521,479	16,165,857	521,479			3,272,428	12,954,570
April	30	1,670,000	50,100,000	16,165,857	538,862	16,165,857	538,862	16,165,857	538,862			1,602,428	14,556,999
May	31	1,670,000	51,770,000	16,165,857	521,479	16,165,857	521,479	8,343,668	521,479	3.5	11,119,681	-25,063	14,531,935
June	30	1,670,000	50,100,000	16,165,857	538,862	16,165,857	538,862	0	0	7.0	22,239,362	-4,471,076	10,060,859
July	31	1,670,000	51,770,000	16,165,857	521,479	16,165,857	521,479	0	0	7.3	23,192,477	-3,754,191	6,306,668
August	31	1,670,000	51,770,000	16,165,857	521,479	16,165,857	521,479	0	0	7.3	23,192,477	-3,754,191	2,552,476
September	30	1,670,000	50,100,000	16,165,857	538,862	16,165,857	538,862	5,388,619	538,862	4.7	14,932,143	-2,552,476	-
October	31	1,670,000	51,770,000	16,165,857	521,479	16,165,857	521,479	16,165,857	521,479			3,272,428	3,272,428
November	30	1,670,000	50,100,000	16,165,857	538,862	16,165,857	538,862	16,165,857	538,862			1,602,428	4,874,857
December	31	1,670,000	51,770,000	16,165,857	521,479	16,165,857	521,479	16,165,857	521,479			3,272,428	8,147,285

Land Application area= 117 acres
5,096,520 sf

Cumulative Storage is the amount of water in the lagoons at the end of the month
The system does not discharge to IP bed C and the irrigation system simultaneously
Discharge to the three IP beds is assumed to be equal
Discharge to IP Bed C was calculated proportionally to the amount of time discharge would occur to Bed C during that month

IP Bed	Loading Limit
A	72
B	72
C	74

Month	A set		B Set		C set	
	Flow (gpd)	Allowable TN Concentration (mg/l)	Flow (gpd)	Allowable TN Concentration (mg/l)	Flow (gpd)	Allowable TN Concentration (mg/l)
January	521,479	16.54	521,479	16.54	521,479	17.0
February	577,352	14.94	577,352	14.94	577,352	15.4
March	521,479	16.54	521,479	16.54	521,479	17.0
April	538,862	16.01	538,862	16.01	538,862	16.5
May	521,479	16.54	521,479	16.54	521,479	17.0
June	538,862	16.01	538,862	16.01	0	
July	521,479	16.54	521,479	16.54	0	
August	521,479	16.54	521,479	16.54	0	
September	538,862	16.01	538,862	16.01	538,862	16.5
October	521,479	16.54	521,479	16.54	521,479	17.0
November	538,862	16.01	538,862	16.01	538,862	16.5
December	521,479	16.54	521,479	16.54	521,479	17.0

14.94 <-Minimum allowable concentration calculated

IP BED HYDRAULIC LOADING

Blegrade Wastewater Master Plan
Treatment and Disposal
IP Bed Design Flows
TD&H Job No. B16-048

Design By: NMR

IP Bed Design Calculations

DENOTES USER INPUT

Infiltration Rate

(from infiltrometer tests performed for 2004 Design Report)

Infiltration Rate= **0.25** inches/min

DEQ-2 recommends using 7 to 10% of measured infiltration rate for Basin Flooding Test

Adjusted Infiltration Rate= 0.0175 inches/min
2.1 feet per day

IP Bed Construction

Number of IP Beds=	**3**	Cell Width=	**100**	feet
Number of Cells per IP Bed=	**5**	Cell Length=	**200**	feet
		Cell Area=	20,000	SF

Allowable Hydraulic Loading

Flow Rate= 314,202 gpd per cell
1,571,010 gpd per IP Bed

Permit Hydraulic Limits

Effluent TN Concentraion= **13.5** mg/l

IP Beds	Permit Limit (ppd)	Allowable Flow Rate (gpd)
Bed A	**72**	638,300
Bed B	**72**	638,300
Bed C	**74**	656,031

IP Loading Cycle

DEQ-2 Recommended Cycles

	Application Period	Drying Period
Summer	1-3 days	4-5 days
Winter	1-3 days	5-10 days

Month	Season	IP Bed A		IP Bed B		IP Bed C	
		(gpd)	(ppd)	(gpd)	(ppd)	(gpd)	(ppd)
January	Winter	362,541	40.9	362,541	40.89	362,541	40.9
February	Winter	362,541	40.9	362,541	40.89	362,541	40.9
March	Winter	362,541	40.9	362,541	40.89	362,541	40.9
April	Summer	589,129	66.5	589,129	66.45	589,129	66.5
May	Summer	589,129	66.5	589,129	66.45	589,129	66.5
June	Summer	589,129	66.5	589,129	66.45	589,129	66.5
July	Summer	589,129	66.5	589,129	66.45	589,129	66.5
August	Summer	589,129	66.5	589,129	66.45	589,129	66.5
September	Summer	589,129	66.5	589,129	66.45	589,129	66.5
October	Winter	362,541	40.9	362,541	40.89	362,541	40.9
November	Winter	362,541	40.9	362,541	40.89	362,541	40.9
December	Winter	362,541	40.9	362,541	40.89	362,541	40.9
	Annual	475,835	53.7	475,835	53.7	475,835	53.7
	Check		OK		OK		OK

DESIGN AGRONOMIC RATES

Belgrade Wastewater Master Plan
Design Agronomic Rates
Irrigation System
TD&H Job No. B116-048

Designed by: NMR

Irrigation System Design Calculations

DENOTES USER INPUT

See attached references for data, tables, charts, etc.

Project Specific Design Criteria:

BOD_5 Influent Concentration =	**408** mg/l	(Based on historic water quality analytical results)
BOD_5 Effluent Concentration =	**61.2** mg/l	(assuming 85% BOD removal)

DEQ-2 Design Criteria:

Circular DEQ-2, Table 93-1

Disposal Method =	**Controlled Discharge**	
Primary Cells Detention Time =	**20** days	
Overall System Detention Time =	**110** days	(Minimum)

Precipitation and Evaporation Data:

Western Regional Climate Center

Lake Evaporation estimated at 70% of pan evaporation.

Wettest-Year-in-10 Precipitation	
Month	**Precipitation Inches**
January	**0.07**
February	**0.27**
March	**0.71**
April	**1.60**
May	**1.73**
June	**2.99**
July	**2.41**
August	**1.01**
September	**3.17**
October	**1.57**
November	**1.64**
December	**1.10**

ANNUAL	18.27	inches/year
PEAK YEAR (1969)	20.04	inches
10-YR FACTOR =	1.0969	

Lake Evaporation			
Month	**Pan Evap. Inches**	**Lake Evap. Factor**	**Lake Evap. Inches**
January	**0.00**	0.7	0.00
February	**0.00**	0.7	0.00
March	**0.00**	0.7	0.00
April	**3.34**	0.7	2.34
May	**5.58**	0.7	3.91
June	**6.03**	0.7	4.22
July	**8.34**	0.7	5.84
August	**7.17**	0.7	5.02
September	**4.57**	0.7	3.20
October	**2.62**	0.7	1.83
November	**0.00**	0.7	0.00
December	**0.00**	0.7	0.00

ANNUAL **26.355** inches/year

Assumptions:

The irrigation season includes half of May And September (16 days each) and all of June, July and August.

Annual Hydraulic Loading Rate:

Circular DEQ-2, Section 121.113.1

The design maximum irrigation application rates, L_H, must be calculated for each month using hydraulic loading rates based on soil permeability and nitrogen loading. The limiting factor, permeability or nutrient uptake, will be used for design.

Soil Permeability Calculations:

Circular DEQ-2, Section 121.113.11

$$L_p = \frac{ETc - P + P_w}{SE}$$

L_p = inches	(hydraulic loading rate)
ETc = inches	(crop evapotranspiration)
P = inches	(precipitation)
P_w = inches	(percolation rate)
SE = fraction	(distribution system efficiency, 0.70 to 0.85 for sprinklers)

Percolation Rate:

EPA Process Design Manual - Land Treatment of Municipal Wastewater (EPA 625/1-81-013)
Web Soil Survey - Saturated Hydraulic Conductivity (Ksat)
DEQ-4 Table 2.1-1 Percolation Rates

Method 1:

The design percolation rate is 4 to 10 percent of the limiting permeability or hydraulic conductivity for the most restrictive soil layer.

Soil Type =	**Attewan Clay Loam**		(Web Soil Survey)
	Beaverell Loam		(Web Soil Survey)
	Beavwan Loam		(Web Soil Survey)
	Beaverell Cobbly Loam		(Web Soil Survey)
	Beaverell-Beavwan Complex		(Web Soil Survey)
Percolation Rate =	**28.5**	min/inch	(DEQ-4 T. 2.1-1, average for Clay loam, silty clay loam)
Percolation Rate =	0.035087719	inches/min	
Percolation Rate =	2.105263158	inches/hr	
Design Percolation Rate =	0.084210526	inches/hr	(4% of Percolation Rate)

Method 2:

Soil Type =	**Attewan Clay Loam**		(Web Soil Survey)
	Beaverell Loam		(Web Soil Survey)
	Beavwan Loam		
	Beaverell Cobbly Loam		(Web Soil Survey)
	Beaverell-Beavwan Complex		(Web Soil Survey)
K_{sat} =	**64.1513**	µm/sec	(Beaverell loam, Beaverell Cobbly Loam, Beaverell-Beavwan Complex, 91.5% of irrigation area.)
Design Percolation Rate =	9.09	inches/hr	

Choose the most conservative Design Percolation Rate:

P_w =	0.084210526	inches/hr	(Design Percolation Rate)

Initial Monthly Percolation:

Use 3:1 drying: wetting ratio for each irrigated month.
The irrigation time is equal to 1/4 of the irrigated days per month.
The Design Percolation Rate is applied to the irrigation time per month.

Month	Irrigated Days	Initial Irrigation Time Hours	P_w Inches
May	**15**	90	7.58
June	**30**	180	15.16
July	**31**	186	15.66
August	**31**	186	15.66
September	**15**	90	7.58
October	**0**	0	0.00

Crop Evapotranspiration Rate:

Figure 4.1 Irrigation Climatic Areas of Montana, August 1986

Climatic Area = **4** **Moderately Low Consumptive Use**

Crop = **Alfalfa**

Estimated Irrigation Requirements
Based on Belgrade's 2004 Design Report

Month	Total Consumptive Use (ETc) Inches
May	**2.50**
June	**5.10**
July	**7.10**
August	**6.60**
September	**3.40**
October	**0.00**

Permeability Water Balance:

$$L_p = \frac{ETc - P + P_w}{SE}$$

Month	ETc Inches	P Inches	P_w Inches	SE	L_p Inches
May	2.50	1.73	7.58	0.85	9.82
June	5.10	2.99	15.16	0.85	20.32
July	7.10	2.41	15.66	0.85	23.94
August	6.60	1.01	15.66	0.85	25.00
September	3.40	3.17	7.58	0.85	9.19
October	0.00	1.57	0.00	0.85	0.00
Annual	24.70	12.88	61.64		88.27

Nitrogen Calculations:

Circular DEQ-2, Section 121.113.12

$$L_N = \frac{U * C}{C_N(1 - f)}$$

L_N = inches (Hydraulic Loading)
U = LB/acre-month (crop uptake as a function of yield)
C = 4.41 (conversion constant)
C_N = mg/L (applied total nitrogen concentration)
f = Nitrogen Loss factor

Crop Nutrient Uptake:

Ranges from 225 to 540 kg/ha-yr
U avg = 382.5 kg/ha-yr
U avg = 342.1 LB/acre-yr (2.21 LB/kg and 0.4047 ha/acre)

Based on NRCS extension service research, assume:
U avg = **183.2** LB/acre-yr (assume occurs during the irrigated days)
(Based on MM 2004 design)

Nitrogen Loss Factor:

per DEQ-2 Section 112.113.12:
Shall not exceed 0.2 for secondary treatment effluent.
Shall not exceed 0.1 for effluent from facilities utilizing nutrient removal methods.
f = **0.1**

Total Nitrogen Concentration:

DEQ-2 Equation 120-4
C_N = **13.5** mg/L

Nitrogen Water Balance:

Month	Total Consumptive Use (ETc) Inches	U LB/acre	L_N Inches
May	2.50	18.54	6.73
June	5.10	37.82	13.73
July	7.10	52.65	19.11
August	6.60	48.94	17.76
September	3.40	25.21	9.15
October	0.00	0.00	0.00
Annual	24.7	183.16	66.48

Limiting Annual Hydraulic Loading Rate:

The smallest Hydraulic Loading Rate per month controls.

Month	L_p Inches	L_N Inches	L_H Inches	Limiting Process	
May	9.82	6.73	**6.73**	Nitrogen	25,050,000
June	20.32	13.73	**13.73**	Nitrogen	50,100,000
July	23.94	19.11	**19.11**	Nitrogen	51,770,000
August	25.00	17.76	**17.76**	Nitrogen	51,770,000
September	9.19	9.15	**9.15**	Nitrogen	25,050,000
October	0.00	0.00	**0.00**		203,740,000
Annual	**88.27**	**66.48**	**66.48**		211,221,981

APPENDIX 6

NORTHWEST PLANNING REGION

BELGRADE WASTEWATER MASTER PLAN
NORTHWEST REGIONAL LIFT STATION
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 5/22/2017

NORTHWEST REGIONAL LIFT STATION SEWER DEMANDS

Estimate the Northwest Regional Lift Station demands using the City's 2014 zoning map.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

BELGRADE WASTEWATER MASTER PLAN
NORTHWEST REGIONAL LIFT STATION
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 5/22/2017

NORTHWEST REGIONAL LIFT STATION SEWER DEMANDS

Sewer Demands for Zoned Areas:

The proposed lift station service area consists of a combination of zoned regions and the existing Crusier Lift Station contributing area. The following table documents the calculations of the design flows from the City zoned areas.

Impact Fee Area Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
	M-1	15.8	5	79	140	11,060
	BP-10	5	0	0	0	0
	BP	60.3	0	0	0	0
	R-3	17.5	26	455	90	40,950
	R-2	302.8	16	4,845	90	436,032
	B-2	16.6	10	166	140	23,240
	R-2	105	16	1,680	90	151,200
Total		**523.0**		**7,225**		**662,482**

ADF = **662,482** gpd
ADF = **461** gpm

Peaking Factor = Qmax/Qavg = (18+P^0.5)/(4+P^0.5)
P = **7.22** thousand persons
Peaking Factor = **3.09**
PHF = **2,047,069** gpd (2.05 MGD)

Add the infiltration rate for the final PHF estimate:
Area = **523.0** acres
City Infiltration Allowance = **50** gal/acre/day
Infiltration = **26,150** gpd (0.03 MGD)

Design PHF = **2,073,219** gpd (2.07 MGD)
Design PHF = **1,440** gpm

Existing Sewer Demands at Cruiser Lift Station:

2017 Draft Wastewater Master Plan (calculated using SCADA event log data)
PHF = **584** gpm
PHF = **840,960** gpd (0.84 MGD)

Total Sewer Demands in the Study Area:

Peak Hour Flow:
PHF = **2,914,179** gpd (2.91 MGD)
PHF = **2,024** gpm

BELGRADE WASTEWATER MASTER PLAN
NORTHWEST REGIONAL LIFT STATION
TD&H Job No. B16-048

Design: CEVJ
Checked: LPH
Date: 5/22/2017

NORTHWEST REGIONAL LIFT STATION SEWER DEMANDS

Use the City of Belgrade Design Standards and Specifications Policy to establish the population, average daily flow, and peak hour flow in the proposed regional lift station study area. Separate engineering reports have been completed for two proposed subdivisions in the study area; the sewer demands estimated in those reports, by others, will be added to the estimated flows in the impact fee areas.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	140	Business Park*
BP-10	0	140	Business Park*
PL-1	0	140	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

BELGRADE WASTEWATER MASTER PLAN
NORTHWEST REGIONAL LIFT STATION
TD&H Job No. B16-048

Design: CEVJ
Checked: LPH
Date: 5/22/2017

NORTHWEST REGIONAL LIFT STATION SEWER DEMANDS

Sewer Demands for the Impact Fees Areas:

The proposed lift station service area consists of a combination of zoned impact fee regions, two proposed subdivisions, and the existing Crusier Lift Station contributing area. The following table documents the calculations of the design flows from the impact fee areas.

Impact Fee Area Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
Impact Fees	R-1	92.5	16	1,480	90	133,200
Impact Fees*	M-1	12.8	5	64	140	8,960
Impact Fees	M-1	9.3	5	47	140	6,510
Impact Fees	BP-10	4.3	0	0	140	0
Impact Fees	PL-1	28.6	0	0	140	0
Impact Fees	BP-10	60.6	0	0	140	0
Impact Fees	R-4	21.5	51	1,097	90	98,685
Impact Fees	PL-1	9.7	0	0	140	0
Impact Fees	R-2	71.4	16	1,142	90	102,816
Impact Fees	R-2	21.7	16	347	90	31,248
Impact Fees	B-2	23.1	10	231	140	32,340
Future Dev.	R-2	83.8	16	1,341	90	120,672
Total		**439.3**		**5,748**		**534,431**

*Area reduced by 3.7 acres to account for a proposed park easement which would produce no flow to the sewer.

Impact Fee Areas:

ADF = **534,431** gpd
ADF = **372** gpm

Peaking Factor = Qmax/Qavg = (18+P^0.5)/(4+P^0.5)
P = **5.75** thousand persons
Peaking Factor = **3.19**
PHF = **1,704,835** gpd (1.70 MGD)

Add the infiltration rate for the final PHF estimate:
Area = **439.3** acres
City Infiltration Allowance = **50** gal/acre/day
Infiltration = **21,965** gpd (0.02 MGD)

Design PHF = **1,726,800** gpd (1.73 MGD)
Design PHF = **1,200** gpm

BELGRADE WASTEWATER MASTER PLAN
NORTHWEST REGIONAL LIFT STATION
TD&H Job No. B16-048

Design: CEVJ
Checked: LPH
Date: 5/22/2017

NORTHWEST REGIONAL LIFT STATION SEWER DEMANDS

Sewer Demands in Proposed Subdivisions:

Original calculations are provided in consultants' design reports.

Henson Subdivision (all phases buildout)

June 14, 2016 *Engineer's Report for Henson Subdivision No. 3, Phase I Water & Sewer Analysis.*

ADF =	**64,102**	gpd	(0.06 MGD)
ADF =	**44.52**	gpm	
PHF =	**249,998**	gpd (less infiltration)	
Infiltration =	**1,552**	gpd	
PHF =	**251,550**	gpd	(0.25 MGD)
PHF =	**175**	gpm	

DLM Prescott Subdivision (aggressive, full buildout in 2022)

June 20, 2016 memo *Prescott Property - estimated water and sewer demand*

ADF =	**296,820**	gpd	(0.30 MGD)
ADF =	**207**	gpm	
PHF =	**1,015,124**	gpd	(1.02 MGD)
PHF =	**705**	gpm	

Existing Sewer Demands at Cruiser Lift Station:

2017 Draft Wastewater Master Plan (calculated using SCADA event log data)

PHF =	**584**	gpm	
PHF =	**840,960**	gpd	(0.84 MGD)

Total Sewer Demands in the Study Area:

Peak Hour Flow:

PHF =	**3,834,434**	gpd	(3.83 MGD)
PHF =	**2,664**	gpm	

LEGEND

- LIFT STATION STUDY AREA BOUNDARY
- EXISTING SEWER MANHOLE
- EXISTING FORCE MAIN
- EXISTING SEWER MAIN
- ZONING BOUNDARY (PRESENT/FUTURE)
- SUBDIVISION BOUNDARY

ZONING INDEX

ZONE	DESCRIPTION
AS	Agricultural Suburban District
BP	Business Park
BP10	Business Park
B2	Highway Business District
B3	Central Business District
M1	Commercial–Light Manufacturing District
M2	Manufacturing and Industrial District
PLI	Public Lands and Institutions
R1	Residential Single Family
R1T	Residential Transitional District
R2	Residential Single Family District Medium Density
R2D	Residential One and Two Family
R2M	Residential Single Family and Manufactured Homes
R3	Residential Medium Density District
R3–Multi	Residential Multi–Family District
R4	Residential Apartment District
R41	Residential Transitional District
RSM	Residential Suburban Manufactured

NOT FOR CONSTRUCTION

REV	DATE	REVISION

TD&H Engineering
406.761.3010 • tdhengineering.com
1800 RIVER DR. NO. • GREAT FALLS, MONTANA 59401

DRAWN BY: CJS
DESIGNED BY:
QUALITY CHECK:
DATE: 08/18/20106
JOB NO. B16-048
FIELDBOOK

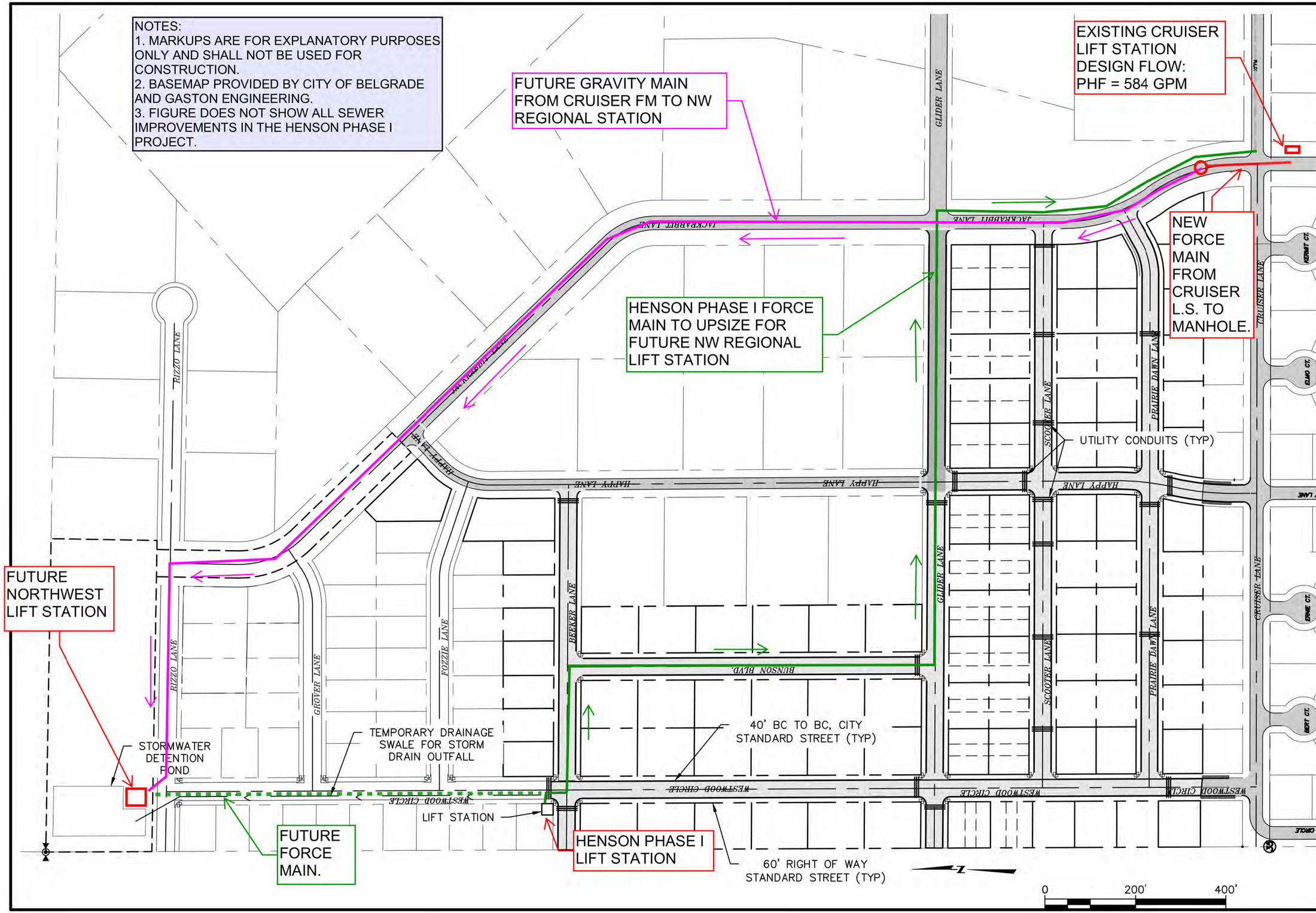
CITY OF BELGRADE MASTER PLAN
BELGRADE, MONTANA

ZONING AREAS STUDY AREA

B16-048 STUDY FIGS.DWG

SHEET 1

NOTES:
1. MARKUPS ARE FOR EXPLANATORY PURPOSES ONLY AND SHALL NOT BE USED FOR CONSTRUCTION.
2. BASEMAP PROVIDED BY CITY OF BELGRADE AND GASTON ENGINEERING.
3. FIGURE DOES NOT SHOW ALL SEWER IMPROVEMENTS IN THE HENSON PHASE I PROJECT.



GASTON ENGINEERING & SURVEYING, PC
PROFESSIONAL PROGRESSIVE PERSONAL

DRAWN BY: BM
CHECKED BY: JO
DRAWING DATE: 6/10/2016
REVISION DATE:

PROJECT: 15-565
DRAWING: 15-565_LYOUT_OVERALL PROJECT

HENSON SUB. NO. 3, PHASE 1
SHEET SET
OVERALL PROJECT
BELGRADE, MT

MONTANA
JEREMY OLSON
No. 15039PE
LICENSED
PROFESSIONAL ENGINEER

C1.2

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/1/2018

BLUE = USER INPUTS
RED = RESULTS

NORTHWEST REGION FUTURE SEWER SIZING

Size the future gravity trunk main and force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **2664** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations													
					75% Full Flow								
Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **27** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter													
Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
27	0.067	0.00067	2.25	3.98	1.44	3.71	2.69	4.17	2.16	0.64	5.9	2,664	2.2
											check:	*0.000*	

Pipe is **64%** full.

Force Main Sizing:

Design Q = **2664** gpm
Design Velocity = **6.0** ft/sec
Flow Area = **0.989** SF
Flow Diameter = **1.122** ft
Flow Diameter = **13.5** inches

Nominal Force Main Diameter = **12.0** inches
Nominal Velocity = **7.6** ft/sec
Is velocity less than 8.0 ft/sec? **Yes.**

BELGRADE REGIONAL LIFT STATION
BELGRADE, MONTANA
TD&H Job No. B16-033

BLUE = USER INPUT
RED = OUTPUT RESULT

Calculated by: CEVJ
Date: 2017-05-22

Northwest Regional Lift Station
Force Main Velocity

There are three design conditions: Northwest Regional Improvements (all areas), Henson Phase I plus Cruiser basin, and Henson Phase I only. Check the velocity in the existing Cruiser Lift Station force main and size a new force main for the Regional Lift Station.

Northwest Regional Lift Station Design Flows:

These flows include the Cruiser Lift Station's existing service area and the future planning area in northwest Belgrade. Two planned subdivisions will contribute to the lift station: Henson and DLM/Prescott. Flow calculations are documented separately.

Peak Hour = **2,664 gpm** (5.94 cfs)

Henson Phase I + Cruiser Lift Station Design Flows:

These flows include the Cruiser Lift Station's existing service area and Phase I of the Henson subdivision. Flow calculations are documented separately.

Peak Hour = **759 gpm** (1.69 cfs)

Henson Phase I Design Flows:

Henson flows documented by others.

Peak Hour = **175 gpm** (0.39 cfs)

Alternative Northwest Regional Lift Station Design Flow:

This flow is based on the City's 2014 zoning. It is included here for informational purposes only.

Peak Hour = **2,024 gpm** (4.51 cfs)

Force Main Velocity Requirements:

EPA and DEQ Minimum Velocity =	**2**	ft/sec
Average Design Velocity =	**6**	ft/sec
Montana DEQ Maximum Velocity =	**8**	ft/sec
EPA Maximum Velocity =	**10**	ft/sec

Analysis and Results:

Use the continuity equation to estimate velocities in the force mains at each design flow.

Legend:	
	Pink cells indicate velocities above 10 ft/sec or below 2 ft/sec.
	Blue cells indicate velocities between 8 ft/sec and 10 ft/sec.

Nominal Pipe Diameter (inches)	Nominal Flow Area (SF)	Northwest Regional Design Flows	Henson Phase I and Cruiser Design Flows	Henson Phase I Design Flows Only	Alternate Northwest Regional Design Flows
		PHF	**PHF**	**PHF**	**PHF**
		2,664 gpm	**759 gpm**	**175 gpm**	**2,024 gpm**
		5.94 cfs	**1.69 cfs**	**0.39 cfs**	**4.51 cfs**
4	0.087	68.0 fps	19.4 fps	4.5 fps	51.7 fps
6	0.196	30.2 fps	8.6 fps	2.0 fps	23.0 fps
8	0.349	17.0 fps	4.8 fps	1.1 fps	12.9 fps
10	0.545	10.9 fps	3.1 fps	0.7 fps	8.3 fps
12	0.785	7.6 fps	2.2 fps	0.5 fps	5.7 fps
14	1.069	5.6 fps	1.6 fps	0.4 fps	4.2 fps

Recommendations:

Force main from Northwest Regional Lift Station to Cruiser force main: **12-inches**

It is also recommended that the City consider allowing Henson subdivision install a temporary 4-inch PE force main from the Phase I Henson Lift Station to the Cruiser force main.

Velocity in existing 10" Cruiser force main at Northwest Regional design flow: **10.9 fps**

A DEQ deviation will be required to approve velocities over 8 fps.

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/6/2018

BLUE = USER INPUTS
RED = RESULTS

CRUISER LIFT STATION FUTURE SEWER SIZING

Size the future gravity trunk main and force main to convey flows to the Northwest Regional Lift Station. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **584** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **12** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
12	0.22	0.0022	1.00	0.79	0.66	3.81	0.55	1.90	0.95	0.29	1.3	584	2.4
											check:	*0*	

Pipe is **66%** full.

Force Main Sizing:

Design Q = **584** gpm
Design Velocity = **6.0** ft/sec
Flow Area = **0.217** SF
Flow Diameter = **0.525** ft
Flow Diameter = **6.3** inches

Nominal Force Main Diameter = **6.0** inches
Nominal Velocity = **6.6** ft/sec
Is velocity less than 8.0 ft/sec? **Yes.**

NORTHEAST PLANNING REGION

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: LPH
Checked: CEVJ
Date: 5/23/2017

BLUE = USER INPUTS
RED = RESULTS

NORTHEAST REGION FUTURE SEWER DEMANDS

Estimate the future sewer demands in the planning region based on planned zoning designations.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

Sewer Demands for Zoned Areas:

The following table documents the calculations of the design flows from the zoned areas.

Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
NE Region	R-1	81.8	16	1,309	90	117,792
Total		**81.8**		**1,309**		**117,792**

ADF =	**117,792**	gpd	
ADF =	**82**	gpm	
Peaking Factor =	Qmax/Qavg = (18+P^0.5)/(4+P^0.5)		
P =	**1.31**	thousand persons	
Peaking Factor =	**3.72**		
PHF =	**438,186**	gpd	(0.44 MGD)

Add the infiltration rate for the final PHF estimate:

Area =	**81.8**	acres	
City Infiltration Allowance =	**50**	gal/acre/day	
Infiltration =	**4,090**	gpd	(0.00 MGD)
Design PHF =	**442,276**	**gpd**	**(0.44 MGD)**
Design PHF =	**308**	**gpm**	

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/2/2018

BLUE = USER INPUTS
RED = RESULTS

NORTHEAST REGION FUTURE SEWER SIZING

Size the future gravity trunk main and force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **308** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **8** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.49	4.14	0.28	1.38	0.58	0.20	0.7	308	2.5
											check:	*0.000*	

Pipe is **74%** full.

EAST PLANNING REGION

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: LPH
Checked: CEVJ
Date: 5/23/2017

BLUE = USER INPUTS
RED = RESULTS

EAST REGION 1 FUTURE SEWER DEMANDS

Estimate the future sewer demands in the planning region based on planned zoning designations.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

Sewer Demands for Zoned Areas:

The following table documents the calculations of the design flows from the zoned areas.

Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
E1 Region	M-1	58.5	5	293	140	40,950
E1 Region	R-2	96.0	16	1,536	90	138,240
Total		**154.5**		**1,829**		**179,190**

ADF = **179,190** gpd
ADF = **125** gpm

Peaking Factor = Qmax/Qavg = (18+P^0.5)/(4+P^0.5)
P = **1.83** thousand persons
Peaking Factor = **3.62**
PHF = **648,668** gpd (0.65 MGD)

Add the infiltration rate for the final PHF estimate:
Area = **154.5** acres
City Infiltration Allowance = **50** gal/acre/day
Infiltration = **7,725** gpd (0.01 MGD)

Design PHF = **656,393 gpd** **(0.66 MGD)**
Design PHF = **456 gpm**

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: LPH
Checked: CEVJ
Date: 5/23/2017

BLUE = USER INPUTS
RED = RESULTS

EAST REGION 2 FUTURE SEWER DEMANDS

Estimate the future sewer demands in the planning region based on planned zoning designations.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

Sewer Demands for Zoned Areas:

The following table documents the calculations of the design flows from the zoned areas.

Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
E2 Region	**PL-1**	**38.4**	0	0	0	0
E2 Region	**R-1**	**51.0**	16	816	90	73,440
E2 Region	**R-3**	**36.0**	26	936	90	84,240
Total		**125.4**		**1,752**		**157,680**

ADF =	**157,680**	gpd	
ADF =	**110**	gpm	
Peaking Factor =	Qmax/Qavg = (18+P^0.5)/(4+P^0.5)		
P =	**1.75**	thousand persons	
Peaking Factor =	**3.63**		
PHF =	**572,378**	gpd	(0.57 MGD)
Add the infiltration rate for the final PHF estimate:			
Area =	**125.4**	acres	
City Infiltration Allowance =	**50**	gal/acre/day	
Infiltration =	**6,270**	gpd	(0.01 MGD)
Design PHF =	**578,648**	**gpd**	**(0.58 MGD)**
Design PHF =	**402**	**gpm**	

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/2/2018

BLUE = USER INPUTS
RED = RESULTS

EAST REGION 2 FUTURE SEWER SIZING

Size the future gravity trunk main and force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **402** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **10** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
10	0.28	0.0028	0.83	0.55	0.55	3.79	0.38	1.58	0.79	0.24	0.9	402	2.3
											check:	*0*	

Pipe is **66%** full.

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/1/2018

BLUE = USER INPUTS
RED = RESULTS

EAST REGIONS 1 AND 2 FUTURE SEWER SIZING

Size the future gravity trunk main and force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **858** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **15** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
15	0.15	0.0015	1.25	1.23	0.82	3.77	0.85	2.36	1.19	0.36	1.9	858	2.2
											check:	*0*	

Pipe is **65%** full.

Force Main Sizing at the Meadowlark Lift Station:

Design Q = **1141** gpm (includes 283 gpm peak hour from Meadowlark Ranch subdivision)
Design Velocity = **6.0** ft/sec
Flow Area = **0.424** SF
Flow Diameter = **0.735** ft
Flow Diameter = **8.8** inches

Nominal Force Main Diameter = **8.0** inches
Nominal Velocity = **7.3** ft/sec
Is velocity less than 8.0 ft/sec? **Yes.**

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/1/2018

BLUE = USER INPUTS
RED = RESULTS

RYEN GLENN GRAVITY CONVEYANCE FUTURE SEWER SIZING

Size the future gravity trunk main to serve the Meadowlark Ranch subdivision and the east planning regions. The trunk main will convey flows to the Ryen Glenn Lift Station. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **1141** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **18** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
18	0.12	0.0012	1.50	1.77	0.92	3.61	1.14	2.71	1.46	0.42	2.5	1,141	2.2
											check:	*0*	

Pipe is **62%** full.

SOUTHEAST PLANNING REGION

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: LPH
Checked: CEVJ
Date: 5/23/2017

BLUE = USER INPUTS
RED = RESULTS

SOUTHEAST REGION FUTURE SEWER DEMANDS

Estimate the future sewer demands in the planning region based on planned zoning designations.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

Sewer Demands for Zoned Areas:

The following table documents the calculations of the design flows from the zoned areas.

Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
SE Region	**M-1**	**162.6**	5	813	140	113,820
SE Region	**B-2**	**132.3**	10	1,323	140	185,220
Total		**294.9**		**2,136**		**299,040**

ADF =	**299,040**	gpd	
ADF =	**208**	gpm	
Peaking Factor =	Qmax/Qavg = (18+P^0.5)/(4+P^0.5)		
P =	**2.14**	thousand persons	
Peaking Factor =	**3.56**		
PHF =	**1,064,582**	gpd	(1.06 MGD)

Add the infiltration rate for the final PHF estimate:

Area =	**294.9**	acres	
City Infiltration Allowance =	**50**	gal/acre/day	
Infiltration =	**14,745**	gpd	(0.01 MGD)
Design PHF =	**1,079,327**	**gpd**	**(1.08 MGD)**
Design PHF =	**750**	**gpm**	

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/6/2018

BLUE = USER INPUTS
RED = RESULTS

SOUTHEAST REGION FUTURE SEWER SIZING

Size the future gravity trunk main and force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **750** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **15** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
15	0.15	0.0015	1.25	1.23	0.75	3.54	0.77	2.21	1.23	0.35	1.7	750	2.2
											check:	*0*	

Pipe is **60%** full.

SOUTH PLANNING REGION

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: LPH
Checked: CEVJ
Date: 5/23/2017

BLUE = USER INPUTS
RED = RESULTS

SOUTH REGION FUTURE SEWER DEMANDS

Estimate the future sewer demands in the planning region based on planned zoning designations.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

Sewer Demands for Zoned Areas:

The following table documents the calculations of the design flows from the zoned areas.

Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
S Region	**B-2**	**28.4**	10	284	140	39,760
S Region	**M-1**	**22.9**	5	115	140	16,030
S Region	**B-2**	**80.8**	10	808	140	113,120
Total		**132.1**		**1,207**		**168,910**

ADF = **168,910** gpd
ADF = **118** gpm

Peaking Factor = Qmax/Qavg = (18+P^0.5)/(4+P^0.5)
P = **1.21** thousand persons
Peaking Factor = **3.75**
PHF = **633,413** gpd (0.63 MGD)

Add the infiltration rate for the final PHF estimate:
Area = **132.1** acres
City Infiltration Allowance = **50** gal/acre/day
Infiltration = **6,605** gpd (0.01 MGD)

Design PHF = **640,018 gpd** **(0.64 MGD)**
Design PHF = **445 gpm**

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/6/2018

BLUE = USER INPUTS
RED = RESULTS

SOUTH REGION FUTURE SEWER SIZING

Size the future gravity trunk main and force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **445** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **10** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
10	0.28	0.0028	0.83	0.55	0.59	4.02	0.42	1.67	0.76	0.25	1.0	445	2.4
											check:	*0*	

Pipe is **71%** full.

SOUTHWEST PLANNING REGION

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: LPH
Checked: CEVJ
Date: 5/23/2017

BLUE = USER INPUTS
RED = RESULTS

SOUTHWEST REGION FUTURE SEWER DEMANDS

Estimate the future sewer demands in the planning region based on planned zoning designations.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

Sewer Demands for Zoned Areas:

The following table documents the calculations of the design flows from the zoned areas.

Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
SW Region	**AS**	**146.9**	18.4	2,703	90	243,266
SW Region	**R-1**	**159.2**	16	2,547	90	229,248
SW Region	**R-2**	**331.5**	16	5,304	90	477,360
SW Region	**B-2**	**70.9**	10	709	140	99,260
Total		**708.5**		**11,263**		**1,049,134**

ADF = **1,049,134** gpd
ADF = **729** gpm

Peaking Factor = Qmax/Qavg = (18+P^0.5)/(4+P^0.5)
P = **11.26** thousand persons
Peaking Factor = **2.9**
PHF = **3,042,490** gpd (3.04 MGD)

Add the infiltration rate for the final PHF estimate:
Area = **708.5** acres
City Infiltration Allowance = **50** gal/acre/day
Infiltration = **35,425** gpd (0.04 MGD)

Design PHF = **3,077,915 gpd** **(3.08 MGD)**
Design PHF = **2,138 gpm**

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/6/2018

BLUE = USER INPUTS
RED = RESULTS

SOUTHWEST REGION FUTURE SEWER SIZING

Size the future gravity trunk main and force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **2138** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **24** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
24	0.08	0.0008	2.00	3.14	1.29	3.72	2.13	3.72	1.92	0.57	4.8	2,138	2.2
											check:	*0*	

Pipe is **64%** full.

Force Main Sizing:

Design Q = **2138** gpm
Design Velocity = **6.0** ft/sec
Flow Area = **0.794** SF
Flow Diameter = **1.005** ft
Flow Diameter = **12.1** inches

Nominal Force Main Diameter = **12.0** inches
Nominal Velocity = **6.1** ft/sec
Is velocity less than 8.0 ft/sec? **Yes.**

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 6/5/2017

BLUE = USER INPUTS
RED = RESULTS

SID #78 LIFT STATION FUTURE SIZING

Size the future force main to accommodate the Southwest Planning Region and SID #78. Design flows documented separately. Utilize City and DEQ design criteria.

Force Main Sizing:

Design Q =	**2728**	gpm
Design Velocity =	**6.0**	ft/sec
Flow Area =	**1.013**	SF
Flow Diameter =	**1.136**	ft
Flow Diameter =	**13.6**	inches
Nominal Force Main Diameter =	**12.0**	inches
Nominal Velocity =	**7.7**	ft/sec
Is velocity less than 8.0 ft/sec?	**Yes.**	

WEST PLANNING REGION

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: LPH
Checked: CEVJ
Date: 5/23/2017

BLUE = USER INPUTS
RED = RESULTS

WEST REGION FUTURE SEWER DEMANDS

Estimate the future sewer demands in the planning region based on planned zoning designations.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

Sewer Demands for Zoned Areas:

The following table documents the calculations of the design flows from the zoned areas.

Average Day Demands						
Description	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
W Region	**M-2**	**25.7**	5	129	140	17,990
W Region	**B-2**	**2.4**	10	24	140	3,360
W Region	**B-2**	**8.9**	10	89	140	12,460
Total		**37.0**		**242**		**33,810**

ADF = **33,810** gpd
ADF = **24** gpm

Peaking Factor = Qmax/Qavg = (18+P^0.5)/(4+P^0.5)
P = **0.24** thousand persons
Peaking Factor = **4.12**
PHF = **139,297** gpd (0.14 MGD)

Add the infiltration rate for the final PHF estimate:
Area = **37.0** acres
City Infiltration Allowance = **50** gal/acre/day
Infiltration = **1,850** gpd (0.00 MGD)

Design PHF = **141,147 gpd** **(0.14 MGD)**
Design PHF = **99 gpm**

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/6/2018

BLUE = USER INPUTS
RED = RESULTS

WEST REGION FUTURE SEWER SIZING

Size the future gravity trunk main and force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **99** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **8** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.25	2.61	0.12	0.87	0.64	0.13	0.2	99	1.9
											check:	*0*	

Pipe is **37%** full.

RYEN GLENN LIFT STATION IMPACTS

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 6/5/2017

BLUE = USER INPUTS
RED = RESULTS

RYEN GLENN LIFT STATION FUTURE SIZING

Size the future force main in the planning region. Design flows documented separately. Utilize City and DEQ design criteria.

Velocity in Existing Force Main:

Design Q =	**1686**	gpm
Force Main Diameter =	**8.0**	inches
Nominal Velocity =	**10.8**	ft/sec

Force Main Sizing:

Design Q =	**1686**	gpm
Design Velocity =	**6.0**	ft/sec
Flow Area =	**0.626**	SF
Flow Diameter =	**0.893**	ft
Flow Diameter =	**10.7**	inches

Nominal Force Main Diameter =	**10.0**	inches
Nominal Velocity =	**6.9**	ft/sec

Is velocity less than 8.0 ft/sec? **Yes.**

INTERSTATE 90 CROSSING IMPACTS

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/6/2018

BLUE = USER INPUTS
RED = RESULTS

INTERSTATE 90 CROSSING - FUTURE SEWER UPSIZING

Size the future sewer mains. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **3173** gpm
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	Existing Slope (ft/100 ft)	Existing Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.444	0.00444	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	330	2.6
10	0.444	0.00444	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.3	597	3.0
12	0.444	0.00444	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	2.2	972	3.4
15	0.444	0.00444	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	3.9	1,762	4.0
18	0.444	0.00444	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	6.4	2,865	4.5
21	0.444	0.00444	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	9.6	4,321	5.0
24	0.444	0.00444	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	13.7	6,169	5.4
27	0.444	0.00444	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	18.8	8,446	5.9
30	0.444	0.00444	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	24.9	11,185	6.3
36	0.444	0.00444	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	40.5	18,188	7.1
42	0.444	0.00444	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	61.1	27,436	7.9

Gravity Main Diameter = **21** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	Existing Slope (ft/100 ft)	Existing Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
21	0.444	0.00444	1.75	2.41	1.05	3.54	1.50	3.10	1.72	0.49	7.1	3,173	4.7
											check:	*0*	

Pipe is **60%** full.

EAST INTERCEPTOR IMPACTS

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 6/13/2017

BLUE = USER INPUTS
RED = RESULTS

EXISTING SEWER DEMANDS TO 21" EAST INTERCEPTOR

Estimate the existing sewer demands contributing to the east interceptor sewer based on planned zoning designations.

Belgrade zoning densities and demands from the Design Standards, Tables 7 and 8:

City of Belgrade Zoning Densities			
Zone	Population Density (persons/acre)	Sewer Demand (gpcd)	Description
R-1	16	90	Residential - Single Family
R-2	16	90	Residential - Single Family - Medium Density
R-2-D	16	90	Residential - One & Two Family
R-2-M	16	90	Residential - Single Family & Manufactured Home
R-3	26	90	Residential - Medium Density District
R-4	51	90	Residential - Apartment District
RS	12	90	Residential - Suburban District
RS-M	25.4	90	Residential - Suburban District - Manufactured Home
AS	18.4	90	Agricultural - Suburban District
M-1	5	140	Commerical - Light Manufacturing
M-2	5	140	Manufacturing & Industrial District
B-1	10	140	Neighborhood Business District
B-2	10	140	Highway Business District
B-3	10	140	Central Business District
BP	0	0	Business Park*
BP-10	0	0	Business Park*
PL-1	0	0	Public Lands & Institutions*
*No population density defined in Belgrade Design Standards			

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 6/13/2017

BLUE = USER INPUTS
RED = RESULTS

EXISTING SEWER DEMANDS TO 21" EAST INTERCEPTOR

Sewer Demands for Zoned Areas:

The following table documents the calculations of the design flows from the zoned areas.

Average Day Demands						
Vicinity to Frontage Road	Zone	Area (acres)	Population Density (persons/acre)	Population (persons)	Sewer Demand (gpcd)	Average Day Demand (gpd)
North	B-2	20.6	10	206	140	28,885
South	R-3	10.3	26	268	90	24,102
South	R-3	29.6	26	770	90	69,264
South	R-2	17.5	16	280	90	25,200
South	PL-1	8.2	0	0	0	0
South	R-1	43.2	16	691	90	62,208
South	R-2	11.3	16	181	90	16,272
South	R-3	2.3	26	60	90	5,382
South	PL-1	2.5	0	0	0	0
South	R-3	9.1	26	237	90	21,294
South	R-4	16.4	51	836	90	75,276
South	R-4	8.3	51	422	90	38,016
South	R-2-M	13.3	16	212	90	19,088
South	R-2	10.7	16	172	90	15,475
Total		**203.3**		**4,335**		**400,461**

ADF = **400,461** gpd
ADF = **279** gpm

Peaking Factor = Qmax/Qavg = (18+P^0.5)/(4+P^0.5)
P = **4.33** thousand persons
Peaking Factor = **3.3**
PHF = **1,321,522** gpd (1.32 MGD)

Add the infiltration rate for the final PHF estimate:
Area = **203.3** acres
City Infiltration Allowance = **50** gal/acre/day
Infiltration = **10,166** gpd (0.01 MGD)

Design PHF = **1,331,688 gpd** **(1.33 MGD)**
Design PHF = **925 gpm**

BELGRADE WASTEWATER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Design: CEVJ
Checked:
Date: 3/6/2018

BLUE = USER INPUTS
RED = RESULTS

EAST INTERCEPTOR - FUTURE SEWER UPSIZING

Size the future sewer main. Design flows documented separately. Utilize City and DEQ design criteria.

Gravity Main Sizing:

Design Q = **2797** gpm (less the existing capacity of the 21" outfall sewer)
n = **0.013** (City of Belgrade Design Standards)
Flow Depth = **75%** (City of Belgrade Design Standards)

Sewer Capacity Calculations

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	75% Full Flow: Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
8	0.4	0.004	0.67	0.35	0.50	4.19	0.28	1.40	0.58	0.20	0.7	313	2.5
10	0.28	0.0028	0.83	0.55	0.63	4.19	0.44	1.75	0.72	0.25	1.1	474	2.4
12	0.22	0.0022	1.00	0.79	0.75	4.19	0.63	2.09	0.87	0.30	1.5	684	2.4
15	0.15	0.0015	1.25	1.23	0.94	4.19	0.99	2.62	1.08	0.38	2.3	1,024	2.3
18	0.12	0.0012	1.50	1.77	1.13	4.19	1.42	3.14	1.30	0.45	3.3	1,489	2.3
21	0.1	0.001	1.75	2.41	1.31	4.19	1.94	3.67	1.52	0.53	4.6	2,051	2.4
24	0.08	0.0008	2.00	3.14	1.50	4.19	2.53	4.19	1.73	0.60	5.8	2,619	2.3
27	0.067	0.00067	2.25	3.98	1.69	4.19	3.20	4.71	1.95	0.68	7.3	3,281	2.3
30	0.058	0.00058	2.50	4.91	1.88	4.19	3.95	5.24	2.17	0.75	9.0	4,043	2.3
36	0.046	0.00046	3.00	7.07	2.25	4.19	5.69	6.28	2.60	0.91	13.0	5,854	2.3
42	0.037	0.00037	3.50	9.62	2.63	4.19	7.74	7.33	3.03	1.06	17.6	7,920	2.3

Gravity Main Diameter = **27** inches (Pipe shall not flow more than 75% full.)

Flow Characteristics at the Design Q and Design Diameter

Sewer Size (inches)	DEQ Minimum Slope (ft/100 ft)	DEQ Minimum Slope (ft/ft)	Diameter (ft)	Pipe Area (SF)	Depth (ft)	Theta (rad)	Flow Area (SF)	Wetted Perimeter (ft)	Top Width (ft)	Hydraulic Radius (ft)	Flow Rate (cfs)	Flow Rate (gpm)	Velocity (ft/s)
27	0.067	0.00067	2.25	3.98	1.49	3.80	2.80	4.28	2.13	0.65	6.2	2,797	2.2
											check:	*0*	

Pipe is **66%** full.

APPENDIX 7A

ALTERNATIVE T-4
SUPPORTING DOCUMENTS

Nicole Rediske - RE: Belgrade Wastewater Lagoon Improvements

From: "Ben Lewis" <blewis@ambienteh2o.com>
To: "'Nicole Rediske'" <Nicole.Rediske@tdhengineering.com>
Date: 3/16/2017 11:26 AM
Subject: RE: Belgrade Wastewater Lagoon Improvements
Cc: "'Camille Johnson'" <Camille.Johnson@tdhengineering.com>, "'Dustin Nett'...
Attachments: Belgrade MT. MARS Budgetary Quote. 3-14-2017 (4).pdf; Belgrade, MT. MARS Basis of Design. 3-14-2017.pdf; Belgrade, MT. NitrOx+D Basis of Design. 3-14-2017.pdf; Belgrade, MT. NitrOx+D Budgetary Quote. 3-13-2017.pdf; 2017 Montana Line Card.pdf

Nicole,

To meet effluent criteria for Belgrade, Triplepoint proposed an aeration upgrade (MARS) followed by Nitrox+D for nitrification and denitrification. Please find corresponding quotes and basis of design for each unit op. Please let me know when a good time would be to schedule a conference call with Triple Point to go over the attached options.

Thank you,

Ben Lewis

AMBIENTE H2O INC. Wastewater & Water Treatment Specialists

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Billings, MT 59102
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PUMPS CLOGGING?? = Deragger II – Don't Chop It, Pump It!!!

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From: Nicole Rediske [Nicole.Rediske@tdhengineering.com]
Sent: Thursday, February 16, 2017 3:10 PM
To: blewis@ambienteh2o.com
Cc: Camille Johnson <Camille.Johnson@tdhengineering.com>; Dustin Nett <Dustin.Nett@tdhengineering.com>; Keith Waring <Keith.Waring@tdhengineering.com>; Matt McGee <Matt.McGee@tdhengineering.com>; Wade DeBoo <Wade.DeBoo@tdhengineering.com>
Subject: Belgrade Wastewater Lagoon Improvements

Good Afternoon Ben,
I am currently working with the City of Belgrade, Montana on a Wastewater Master Plan. Part of that plan is to assess their current treatment facility and look at possible improvements. The City discharges to groundwater though three IP beds. Their discharge permit sets limits on the maximum daily total nitrogen load to each bed. Would you be able to provide an estimate for a TriplePoint system's performance for the City of Belgrade?
I have listed some of the properties of the existing system below as well as attached influent concentration data from November 2013 to December 2016.

- This is a municipal system that does not take in any industrial waste
- Current system was constructed in 2004
- Currently there are three ponds, 2 treatment ponds and 1 storage pond
- The treated wastewater is disposed of through a combination of 3 IP beds and land application though irrigation
    - Ponds 1 & 2 (treatment ponds)
        - Aerated Lagoons
        - Static tube aerators
        - Water surface area is about 7 acres each. (554' x 550')
        - Operating depth is 10 feet in both
        - Each has a volume of about 16 MG
        - Sides slopes are 4:1
        - 7 feet of free board
    - Pond 3 (storage pond)
        - Water surface area is about 15.8 acres (580' X 1185')
        - Surface aerators
        - Operating depth is 19.25 feet
        - Volume is 81.5 MG
        - Side slopes are 3:1
        - 3 feet of free board
    - If at all possible, we would like to keep the same footprint
- Design flows
    - Average day=1.67 MG
    - Peaking factor=2.2
    - Peak hour flow=3.67 MG

- Average influent wastewater data

    - Ammonia (as N) = 34.3 mg/l
    - Total Nitrogen = 63.5 mg/l
    - BOD = 407.7 mg/l
    - TSS= 271.3 mg/l
    - Nitrates + Nitrites (as N)= 0.5 mg/l
    - TKN (as N)=63.0 mg/l

I am most curious about the amount of total nitrogen removal a TriplePoint system can a achieve without increasing the footprint of the existing lagoons.
Please do not hesitate to contact me and 406-761-3010 if you have any questions or need additional information.
Thank you,

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

Virus-free. www.avast.com

Lagoons Do It Better.

It's our belief, our motto, and our mission.

Lagoons provide reliable, cost-effective, and low maintenance wastewater treatment. Lagoon owners are increasingly challenged to meet stricter effluent requirements, expand capacity, or simply upgrade antiquated equipment. That's why we have dedicated our 30+ years of lagoon engineering expertise to rehabilitating lagoons—innovating treatment technologies and processes that leverage existing infrastructure while minimizing capital expense. Our cutting-edge solutions, including efficient lagoon aeration, cold weather ammonia-nitrogen removal, advanced lagoon treatment, and tertiary phosphorus reduction, allow lagoons to be reinvented instead of replaced.

Triplepoint is committed to being your complete lagoon solution provider, with lagoon products and processes that are reliable, cost-effective, and easy to operate. We believe in partnering with you to plan, design, and implement the best possible treatment system for your facility—one that we guarantee will work; one that we stand behind.

Contact us:

Triplepoint Water Technologies
1140 W. Lake Street
Oak Park, IL 60301

Call: (800) 654 9307
info@triplepointwater.com
www.triplepointwater.com

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LAGOONS Do it better.™

Water Environment Federation Member
the water quality people®

MARS AERATION SYSTEM

Mixing. Aerating. Lagoons.

triplepoint™ water technologies

THE MARS AERATION SYSTEM

The MARS Aeration System utilizes industry-leading submerged aeration diffuser technology, providing effective mixing and efficient aeration in a portable unit. MARS Aerators are simple to install: each self-weighted unit is connected to an on-shore air supply via flexible weighted tubing and lowered into the water. Maintenance is just as easy and can be completed from the surface without incurring system downtime. This modular design allows for the MARS to be implemented in any size wastewater facility, from single user systems to full-scale facilities.

EFFICIENT MIXING & AERATING

ONE PORTABLE UNIT

DOUBLE BUBBLE TECHNOLOGY™

Coarse Bubble Mixing: Large bubbles are released at the bottom of the static tube creating a draft that pulls water and liquefied organic matter up from the basin floor and through the unit. This produces a highly agitated water column that thoroughly mixes and circulates the entire wastewater tank or lagoon.

Fine Bubble Efficiency: Fine bubble diffusers surround the static tube, maximizing oxygen transfer efficiency (OTE) while minimizing energy consumption. Enhanced by coarse bubble mixing, the fine bubble oxygenation provides the ideal environment for biological treatment.

Optimized Energy Distribution: The MARS Technology's modular design allows for treatment to be evenly distributed throughout the entire lagoon, mixing and aerating from the basin floor to the surface.

COST EFFICIENT INSTALLATION

Ease of Installation: The self-weighted, portable, and modular design allows an entire MARS Aeration System to be quickly installed from the surface without ever taking the lagoon offline. This keeps effluent levels within permit, even during a system-wide upgrade.

High Airflow and Mixing Capacity: Due to the MARS' industry leading high airflow and mixing capabilities, the total number of units necessary to treat a facility is minimized. As a result, costs from installation materials, labor, and long-term maintenance are all greatly decreased.

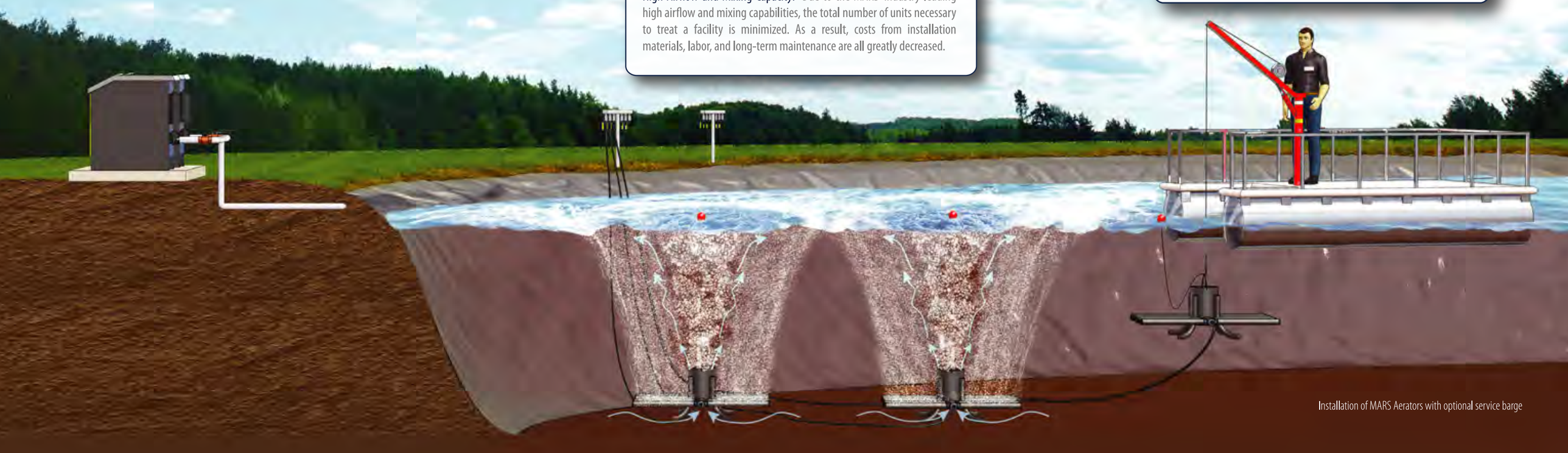
LOWER MAINTENANCE COSTS

Ease of Maintenance: Each MARS Aerator is self-weighted, portable and equipped with a stainless steel tether and locator float. When necessary, individual units can be easily lifted to the surface for servicing without the expense of dewatering or the inconvenience of system downtime.

Centralized Air Supply: Air can be supplied to the entire MARS Aeration System by a single, centralized on-shore blower. If needed, additional blowers can be provided to meet sizing, layout, or redundancy requirements. For further energy savings and control, Variable Frequency Drives (VFD) and dissolved oxygen (DO) meters can be incorporated.

Anti-Fouling Design: The MARS Aerator resists fouling in several ways:

a. Utilizing self-checked fine & coarse bubble diffusers
b. Using self-cleaning EPDM membranes
c. Elevating the diffusers above accumulated solids
d. Eliminating all submerged moving parts



Installation of MARS Aerators with optional service barge

MARS PRODUCT LINE

The versatility and portability of the MARS Aerator make it ideal for wastewater facility retrofits. MARS Aeration is frequently used to upgrade treatment plants with clogged fine bubble diffusers, inefficient coarse bubble aerators, or broken down surface aerators. Durable construction, fast and simple installation, and low operation and maintenance costs, coupled with its superior oxygenation and mixing performance, make the MARS Aerator the preferred choice for efficiency, reliability, and longevity.

MODELS OPTIMIZED FOR YOUR APPLICATION

The MARS Aeration System includes a broad range of product models and options. Triplepoint's engineering team designs systems that are customized to meet your facility's unique requirements while targeting the fastest possible project payback period—often 12-36 months.

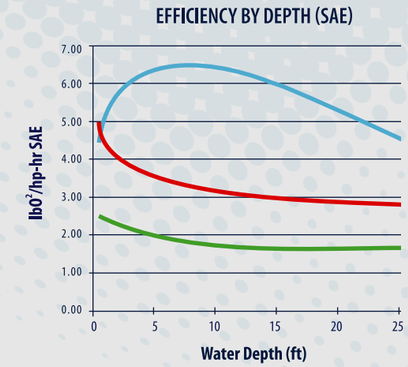
DESIGNED FOR RELIABILITY

All products are manufactured in the USA from the finest industrial-grade materials and have proven resilient in the harshest municipal and industrial wastewater environments. The MARS even excels at cold-weather operation, as all equipment is installed below the surface of the water. Whether it's the compact, rugged frame, stainless steel fittings, lack of moving parts, or the Anti-Fouling diffusers, every component has been selected and tested to provide many years of worry-free operation.

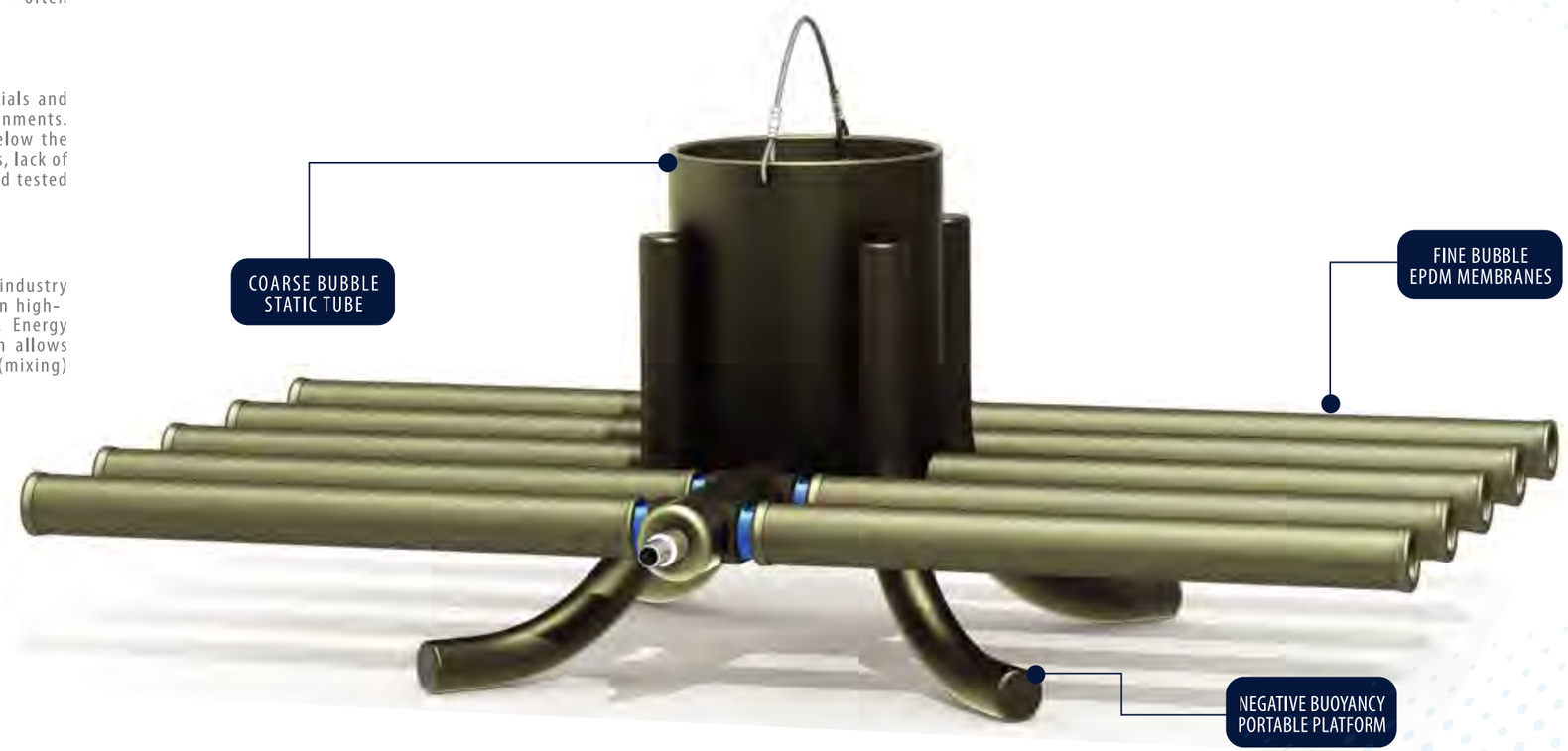
ENERGY EFFICIENCY

Extensive independent testing has proven that the MARS Aerator has a best-in-industry Standard Aeration Efficiency (SAE). The MARS is 50-60% more energy efficient than high-speed surface aerators and 40-50% more efficient than coarse bubble diffusers. Energy efficiency is further enhanced by the patented Double-Bubble Technology, which allows custom optimization of each system's fine bubble (oxygenation) and coarse bubble (mixing) demands.

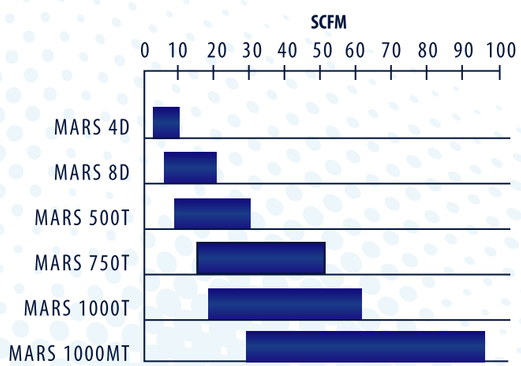
AERATION EFFICIENCY COMPARISON

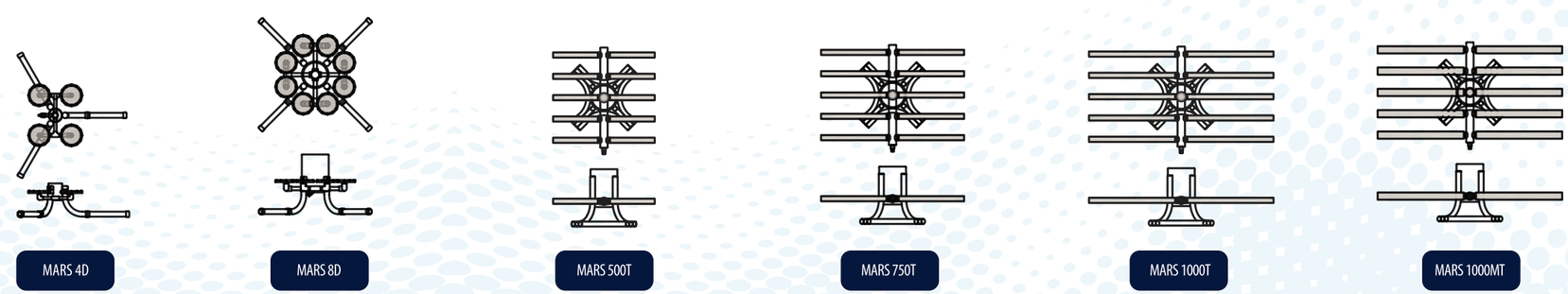


*Based on lab testing in clean water. Not for design purposes.



MARS RECOMMENDED AIRFLOW





YOUR SOLUTION IS OUR GOAL

30 YEARS OF AERATION EXPERIENCE AT YOUR SERVICE

Throughout your entire project, from concept plan to long-term operation, Triplepoint seeks to partner with you to achieve the lowest possible lifecycle costs. We don't sell products - we provide solutions.

OPTIMIZED FOR YOUR APPLICATION

We have a saying here at Triplepoint: "Good data, good decisions." So, when we combine 30+ years of wastewater treatment plant design, construction, and operation experience with good hard data from your wastewater treatment facility, we ensure your project is designed the right way, the first time.

Through a comprehensive understanding of your specific application, our engineering team can assist you throughout the entire process--from design collaboration to equipment specification, from preliminary AutoCAD layouts to final construction documents, and from concept to startup. We partner with you to provide a thorough facility assessment and an authentic long-term solution with the lowest possible life-cycle cost.

INSTALLATION & LIFETIME SUPPORT

INSTALLATION CONTRACTING & SUPERVISION

At Triplepoint, we understand that a plan is only as good as its implementation, and we are committed to making every startup a successful one. That is why we offer professional installation supervision with every complete MARS Aeration System.

LIFETIME PRODUCT SUPPORT

Every MARS Aeration System is backed by an unequivocal commitment to lifetime support. Triplepoint has a team of product support personnel that is dedicated to helping customers operate and maintain their systems as efficiently as possible.

MARS Installation prior to lagoon fill, West Jackson County WWTP

triplepoint environmental

Midwest Office
1140 W. Lake St | Suite 201 | Oak Park | IL 60301

Tel: 312 428 4634 | Fax: 312 957 4712
information@triplepointwater.com | triplepointwater.com

MARS Basis of Design

Date: 3/14/2017
Project Name: Belgrade, MT
Project Number: 2672

Biological Oxygen (BOD) Calculations

Removal of BOD (and CBOD) takes place naturally in an aerated lagoon. The Characteristic Equation for treatment efficiency of 5-Day Biological Oxygen Demand is given in Equation 1, at bottom of report. These calculations are used to size the lagoons. They are independent of the aeration calculations and assume that sufficient dissolved oxygen levels are maintained in the water. The equation is dependent on time and temperature. For lagoons operated in series, the equation is applied separately to each cell and the results are combined.

Aeration Requirement Calculations

Aeration calculations are more complicated than biological calculations as they depend on several factors. These include:

- Site conditions, such as treatment depth, elevation, and temperature.
- Design parameters, such as minimum dissolved oxygen (DO) level and oxygen supply rate.
- Actual Oxygen Requirement (AOR) which is based on the nutrient loading rates (these can include BOD/CBOD and TKN/NH_3-N and are based on the product of nutrient concentrations and the wastewater flow-rate).
- Type of aerator
- Oxygen transfer efficiency (OTE) of the aerator, which should be measured by an independent lab.
- Field condition adjustments (see Equation 2, below).
- Mixing requirements, such as complete or partial mix. The former is generally only required for activated sludge basins (ASB) or other high strength processes with short detention times.

Aerated Lagoons - Long Treatment Times

Aerated lagoons are typified by their comparatively large size and long treatment times (usually greater than 10 days). Influent concentrations are low to moderate (usually less than 300 mg/L of BOD). The bulk of the treatment takes place aerobically with additional anaerobic respiration taking place on the lagoon floor. Aerated lagoons do not generally have a mixed liquor suspended solids (MLSS) or return activated sludge (RAS) component. Partial mixing is required to prevent stratification and eliminate dead-zones; however, complete mix is not necessary.

Aerated lagoons are typically designed to operate at a minimum DO level of 2 mg/L. Oxygen is usually supplied at a rate of 1.5 times the BOD demand. If nitrification/denitrification takes place, the oxygen supply rate is designed for 4.6 times the nitrogenous oxygen demand (NBOD).

Activated Sludge Basins (ASB)

Activated sludge basins (ASB) and other related wastewater tanks and lagoons are characterized by short treatment times (usually from 1 to 5 days), high wastewater strengths, and an active biomass that must be maintained in

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suspension to prevent rapid sludge accumulation. A high strength (greater than 2,000 mg/L) return activated sludge (RAS) component is usually fed back into the basin from a downstream clarifier. Biological nutrient removal is much faster in these basins.

ASBs are typically designed to operate at a minimum DO level of 1 to 2 mg/L. Oxygen is supplied at a rate of 1.0 to 1.5 times the BOD demand. If nitrification/denitrification takes place, the oxygen supply rate is designed for 4.0 to 4.6 times the nitrogenous oxygen demand (NBOD). Aeration system is based on both oxygenation requirements and complete mix requirements, whichever is greater.

TRIPLEPOINT ENVIRONMENTAL
Detailed Design Calculations: MARS
Belgrade, MT

SUMMARY - General Design Parameters

V3.3.4		**Design Scenario Name**		**Design**	**Nitrification**
	1	Influent Flowrate	MGD	1.670	1.670
	2	Influent Concentration	mg/L	407.7	407.7
	3	Effluent Concentration (summer)	mg/L	22.4	22.4
	4	Effluent Concentration (winter)	mg/L	58.6	58.6
	5	Actual Oxygen Supplied	lb/day	8038.6	11240.3
	6	Number of Aerators		180	246
	7	Estimated Tubing Length	ft	3400	5800
	8	Airflow	scfm	6093	8589
	9	Design Pressure (includes cushion)	psig	6.18	6.19
	10	Brake Horsepower	bhp	175.40	247.46
	11	Min. Design Horsepower	hp	252	356

---

1. $FTE = \alpha\ (SOTE)\ \theta^{(T-20)}\ (\beta\ C^*_{\infty T} - DO) \div C^*_{\infty 20}$ *field transfer efficiency*

   Where,

α	contaminant factor {contaminants, depth, bubble-size} (range: 0.40 – 0.70)
β	TDS factor {total dissolved solids} (range: 0.90-1.00)
$\theta = 1.024$	temperature factor
DO	target dissolved oxygen level (mg/L)
$C^*_{\infty T}$	saturation oxygen concentration at site – adjusted for water depth
$C^*_{\infty 20}$	sat. oxygen concentration at STP conditions – adjusted for water depth
T	water temperature (Celsius)

2. Airflow = AOR / (25.056 * FTE)
3. $E = 2.3 * k * t / (1 + 2.3 * k * t)$ *biological treatment efficiency*

   Where,

k = varies	kinetic coefficient {related to temperature} (range: 0.06 to 0.12)
t = time	treatment time in days

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SUMMARY - Biological Treatment Calculations

	Item	Description	Units	Design	Nitrification
		Number of Treatment Cells		2	2
		Flow Regime		Series	Series
		Site Elevation - HWL	MSL - ft	4470	4470
Cell 1					
	1	Wastewater Flowrate	MGD	1.670	1.670
	2	Treatment Volume	M-Gal	19.5	19.5
	3	Treatment Time	days	11.7	11.7
	4	Design Water Temp	°C	20	20
	5	Treatment Type	-	Partial Mix	Partial Mix
	6	Standard Reaction Rate, k_{20}	$days^{-1}$	0.28	0.28
	7	Design Reaction Rate, k_T	$days^{-1}$	0.122	0.122
	8	Biological Treatment Efficiency	%	76.5%	76.5%
	9	Influent BOD Loading	lb/day	5,671	5,671
	10	Influent BOD Concentration	mg/L	407.7	407.7
	11	BOD Removed	lb/day	4,341	4,341
	12	Effluent BOD Loading	lb/day	1,330	1,330
	13	Effluent BOD Concentration	mg/L	95.6	95.6
	14	Influent NBOD Loading	lb/day	883	883
	15	Influent NBOD Concentration	mg/L	63.4	63.4
	16	NBOD Removed* (Assumed)	lb/day	-	177
	17	Effluent NBOD Loading*	lb/day	883	707
	18	Effluent NBOD Concentration*	mg/L	63	51
Cell 2					
	19	Wastewater Flowrate	MGD	1.670	1.670
	20	Treatment Volume	M-Gal	19.5	19.5
	21	Treatment Time	days	11.7	11.7
	22	Design Water Temp	°C	20	20
	23	Treatment Type	-	Partial Mix	Partial Mix
	24	Standard Reaction Rate, k_{20}	$days^{-1}$	0.28	0.28
	25	Design Reaction Rate, k_T	$days^{-1}$	0.122	0.122
	26	Biological Treatment Efficiency	%	76.5%	76.5%
	27	Influent BOD Loading	lb/day	1330	1330
	28	Influent BOD Concentration	mg/L	95.6	95.6
	29	BOD Removed	lb/day	1018	1018
	30	Effluent BOD Loading	lb/day	312	312
	31	Effluent BOD Concentration	mg/L	22.4	22.4
	32	Influent NBOD Loading	lb/day	883	707
	33	Influent NBOD Concentration	mg/L	63.4	50.7
	34	NBOD Removed* (Assumed)	lb/day	-	519
	35	Effluent NBOD Loading*	lb/day	883	187
	36	Effluent NBOD Concentration*	mg/L	63	13.5

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SUMMARY - Aeration Calculations

	Item	Description	Units	Design	Nitrification
Cell 1					
	1	Lagoon Elevation	ft, MSL	4470	4470
	2	Lagoon Side Water Depth	ft	10	10
	3	Air Release Depth	ft	9.25	9.25
	4	O_2 Loading Factor (BOD_5)	lb-O2/lb-BOD	1.5	1.5
	5	O_2 Loading Factor ($NBOD_5$)	lb-O2/lb-NBOD	4.6	4.6
	6	AOR	lb/day	6511	7324
	7	SOTE/ft	%/ft	1.96%	1.93%
	8	SOTE	%	18.11%	17.89%
	9	Design DO Concentration	mg/L	2.0	2.0
	10	Alpha-value, α		0.60	0.60
	11	Beta-value, β		0.95	0.95
	12	Theta-value, θ		1.02	1.02
	13	FTE		5.25%	5.18%
	14	Air requirement	scfm	4953	5639
	15	Airflow per aeration unit	scfm/unit	34.4	36.1
	16	Number of aeration units	units	144	156
	17	Water Pressure	psi	4.01	4.01
	18	Aerator Pressure Loss	psi	0.74	0.75
	19	Header/Feeder Pressure Allowance	psi	0.43	0.44
	20	Total Operating Pressure	psig	5.18	5.19
	21	Design Motor Pressure	psig	6.18	6.19
Cell 2					
	22	Lagoon Elevation	ft, MSL	4470	4470
	23	Lagoon Side Water Depth	ft	10	10
	24	Air Release Depth	ft	9.25	9.25
	25	O_2 Loading Factor (BOD_5)	lb-O2/lb-BOD	1.5	1.5
	26	O_2 Loading Factor ($NBOD_5$)	lb-O2/lb-NBOD	4.6	4.6
	27	AOR	lb/day	1527	3916
	28	SOTE/ft	%/ft	2.00%	1.98%
	29	SOTE	%	18.46%	18.29%
	30	Design DO Concentration	mg/L	2.0	2.0
	31	Alpha-value, α		0.60	0.60
	32	Beta-value, β		0.95	0.95
	33	Theta-value, θ		1.02	1.02
	34	FTE		5.35%	5.30%
	35	Air requirement	cfm	1140	2950
	36	Airflow per aeration unit	cfm	31.7	32.8
	37	Number of aeration units	units	36	90
	38	Water Pressure	psi	4.01	4.01
	39	Aerator Pressure Loss	psi	0.74	0.74
	40	Header/Feeder Pressure Allowance	psi	0.43	0.43
	41	Total Operating Pressure	psig	5.17	5.18
	42	Design Motor Pressure	psig	6.17	6.18

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Tel: 312 428 4634 | Fax: 312 957 4712
information@triplepointwater.com | triplepointwater.com

MARS Budgetary Quote

Date: 3/14/2017
Project Name: Belgrade, MT
Project Number: 2672

QUOTE TO:

Nicole Rediske
TD&H Engineering

C/O:
Ben Lewis
Ambiente H2O

PREPARED BY:

Tom Daugherty, Western Regional Manager
Triplepoint Environmental LLC

Phone: (208) 699-7090
Email: tomd@tpenv.com

MARS™ AERATION EQUIPMENT COSTS

MARS AERATOR System Equipment: Design

- Designed to Treat 1.670 MGD and Supply 8038.6-lbs of Oxygen Per Day.
- Capable of injecting air at 6093 SCFM and 6.18 PSI.
- **Total Cost: $670,650**

MARS Aeration Package: Design	Quantity	Unit
MARS 750T Aerators with EPDM Membranes	180	SET
1.5'' Barbed Fittings: Stainless Steel	180	EA
1.5" Weighted Flexible Tubing	3300	LF
Aeration Orifice Plate: Air Balancing	180	EA
1.5" Full Port Ball Valve & Fittings: Stainless Steel	180	EA
Hose Mender: Stainless Steel	4	SET
Kaeser Blower FB791C 100HP: Duty	3	EA
Kaeser Blower FB791C 100HP: Standby	1	EA
Blower Starter Panel: NEMA 3R	1	EA

NOT Included: Optional Items

Real Time Monitoring: DO Probe.....$10,943.00
(Optional DO Control with Blower VFD: Integrated)
Triplepoint Installation Supervision.....$3,600.00
Kaeser Blower Startup & Installation.....$2,000.00
Baffle Curtain: 6730 RX-5.....(To Be Determined)

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MARS™ AERATION EQUIPMENT COSTS

MARS AERATOR System Equipment: Nitrification

- Designed to Treat 0.1.670 MGD and Supply 11240.3-lbs of Oxygen Per Day.
- Capable of injecting air at 8589 SCFM and 6.19 PSI.
- **Total Cost: $898,260**

MARS Aeration Package: Nitrification	Quantity	Unit
MARS 750T Aerators with EPDM Membranes	246	SET
1.5'' Barbed Fittings: Stainless Steel	246	EA
1.5" Weighted Flexible Tubing	5700	LF
Aeration Orifice Plate: Air Balancing	246	EA
1.5" Full Port Ball Valve & Fittings: Stainless Steel	246	EA
Hose Mender: Stainless Steel	8	SET
Kaeser Blower FB791C 100HP: Duty	4	EA
Kaeser Blower FB791C 100HP: Standby	1	EA
Blower Starter Panel: NEMA 3R	1	EA

NOT Included: Optional Items

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(Optional DO Control with Blower VFD: Integrated)
Triplepoint Installation Supervision……$3,600.00
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Baffle Curtain: 6730 RX-5……(To Be Determined)

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Triplepoint Environmental

Your Installation Is Our Flagship

Triplepoint Environmental is a company focused on serving the treatment needs of wastewater lagoon systems across North America.

Born out of 30+ years of lagoon engineering expertise, Triplepoint is dedicated to constantly improving treatment processes by refining proven technologies and adapting them for the benefit of lagoon operators.

Our goal is to create cutting-edge solutions that are reliable, cost-effective, and easy to operate. Triplepoint believes in partnering with lagoon operators to plan, design, and implement the best possible treatment solution; we believe in a shared legacy, one in which every installation is our flagship.

triplepoint™ environmental

Made in USA

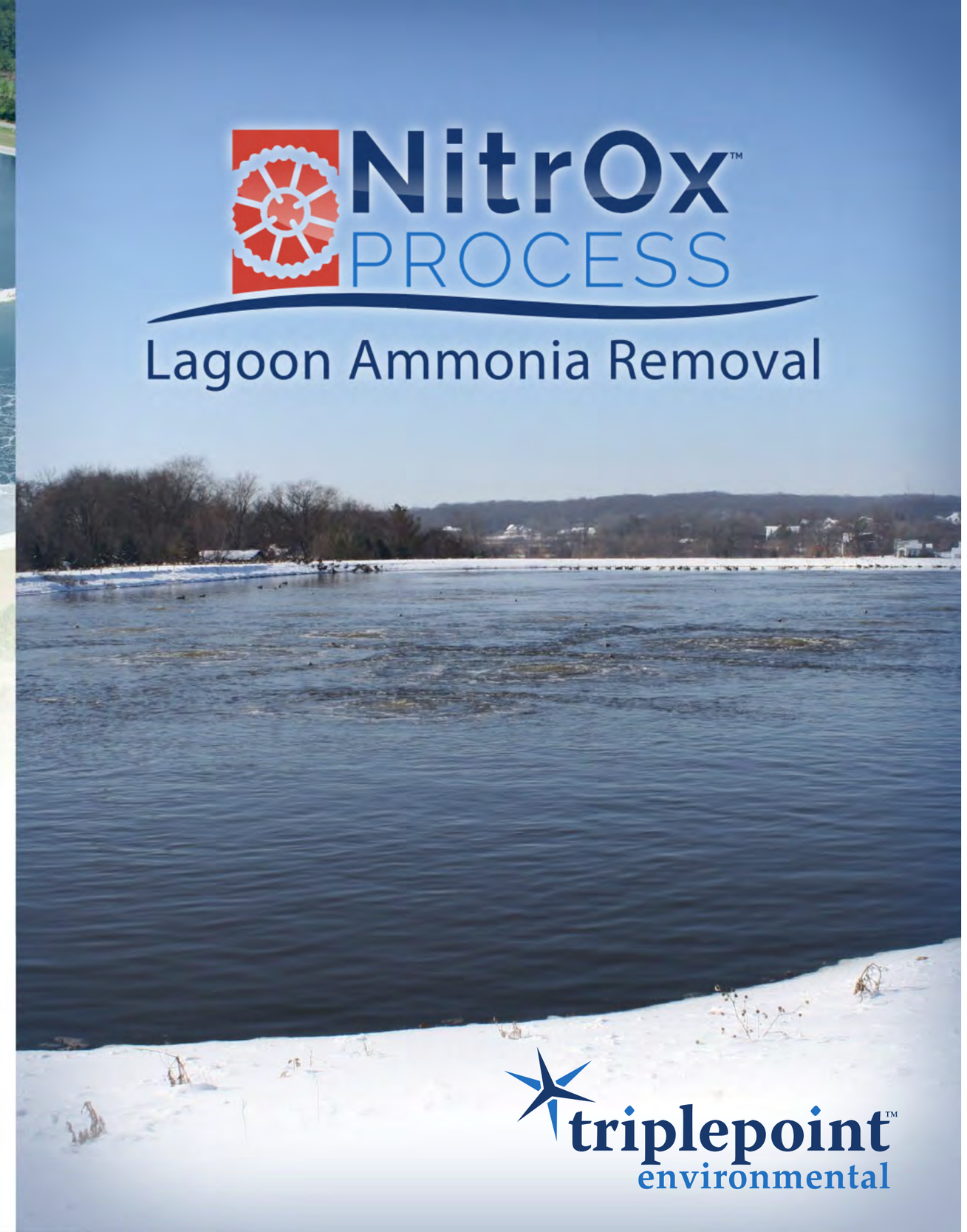
Water Environment Federation Member
the water quality people

Contact us:
Triplepoint Environmental
1140 W. Lake Street
Oak Park, IL 60301

Call: (800) 654 9307
info@triplepointenv.com
www.triplepointenv.com

NitrOx™ PROCESS

Lagoon Ammonia Removal



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NitrOx™ Process

The patent-pending **NitrOx Process** features a thermally regulated nitrification reactor specifically designed to remove ammonia from your lagoon effluent. When winter wastewater temperatures fall those few months a year, the NitrOx System cost-effectively heats up the water—just a few degrees—and fosters the ideal biomass to achieve rapid nitrification. The NitrOx System integrates with your existing infrastructure and can even be configured to address BOD and TN problems while economically achieving near complete ammonia removal at any lagoon temperature.

NitrOx™ PROCESS

Lagoon Ammonia Removal

FINANCIALLY FEASIBLE

1. **Low Capital Costs:** Any required facility upgrade should not be prohibitively expensive. Your lagoons are already accomplishing the majority of the required treatment, and we harness that resource by incorporating the NitrOx Reactor directly into your existing process for the sole purpose of ammonia removal. This helps to keep your capital costs low, minimizing the financial burden of plant upgrades.

2. **Simple Operation:** Lagoons are simple to operate—they are low maintenance, low hassle, and offer lots of flexibility—making them the perfect wastewater treatment solution for small communities. We designed the NitrOx Reactor with precisely this in mind: Self-cleaning media, robust coarse bubble aeration, and automated temperature control are just some of the features that keep maintenance low and operation simple.

3. **Built to Last:** Wastewater systems must be designed to stand the test of time. Lagoons are among the most robust treatment plants available, and the NitrOx Reactor is built to last just as long without replacement. Concrete and stainless steel materials ensure that your infrastructure remains viable for twenty plus years.

PROVEN & PREDICTABLE

1. **Decades of Performance:** We believe in evolution, not revolution, and that's why the NitrOx Reactor integrates technology that was not only proven but perfected over decades, with thousands of installations in operation around the world. By adapting this technology to the specific needs of lagoon systems, we leverage proven nitrification performance to ensure your system reliably keeps you in compliance.

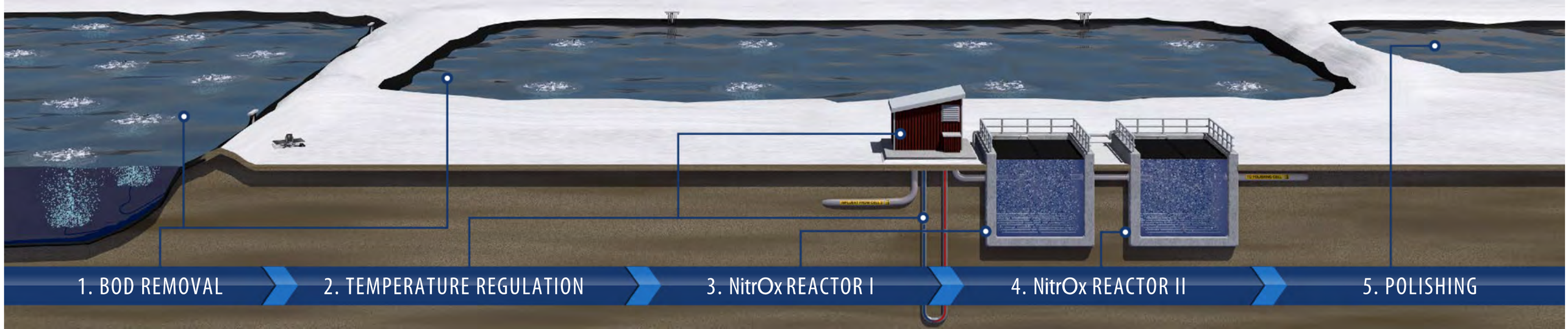
2. **Independently Verified:** We believe good data leads to good decisions. Backed by over 50 independent research papers spanning decades of study, as well as by firmly established kinetics, the NitrOx Reactor is the most proven and predictable lagoon ammonia solution available.

CONTROLLED NITRIFICATION

1. **Controlled Temperature:** Controlled processes yield controlled results. By thermally regulating the influent and insulating to prevent heat loss, the NitrOx Reactor consistently meets strict ammonia limits no matter how cold or unpredictable your winters are.

2. **Controlled Biomass:** The NitrOx Reactor cultivates a dense collection of nitrifying bacteria by utilizing millions of individual attached-growth media. This population of nitrifiers is thousands of times larger than what occurs naturally in your lagoon, providing for rapid ammonia removal—even in cold weather.

3. **Controlled Mixing & Aeration:** The NitrOx Reactor incorporates a robust complete-mix aeration system that ensures that the ammonia, bacteria, and oxygen are in continuous contact. With the entire basin thoroughly mixed, there are no underutilized "dead zones"—ultimately ensuring that every single gallon of your wastewater is treated to precise requirements.



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NitrOx Basis of Design

Date: 3/14/2017
Project Name: Belgrade, MT
Project Number: 2672

The NitrOx™ Process

The patent pending NitrOx Process was developed based on the principle that nitrification will reliably occur when the proper conditions are created. For wastewater lagoon systems that receive primarily domestic waste, the critical conditions required for nitrification include:

1. **CBOD** of 20-30 mg/L
2. **Dissolved oxygen** of 4.6 lb/O2 per pound of NH3-N (Metcalf & Eddy)
3. **Sufficient Population of Nitrifying bacteria**
4. Given sufficient Nitrifying bacteria, a **water temperature of 4-5 ºC**

NitrOx Process utilizes the existing lagoon infrastructure for 90% BOD removal, after which nitrifying bacteria begin to nitrify. The effluent from the lagoons then flows hydraulically or is pumped into a two-stage nitrification reactor. In colder climates where the winter water temperature drops below 4 ºC, a thermal regulation heat exchanger is added in order to increase the water temperature; typically, only a few degrees during the coldest months of the year. In the two NitrOx reactor cells, there are millions of individual biofilm carriers that provide a habitat for nitrifying bacteria –ensuring that there are sufficient nitrifying bacteria even in the coldest water conditions. Each Nitrox reactor cell has a stainless-steel aeration grid to provide the necessary oxygen, as well as to create a complete mix environment to keep the biofilm carriers in constant motion. The two cells are covered with floating insulated covers to mitigate heat loss and the media is kept in the tanks with stainless steel sieves. Finally, the effluent from the second NitrOx reactor is discharged into a final polishing/clarification lagoon prior to the ultimate discharge from the lagoon system.

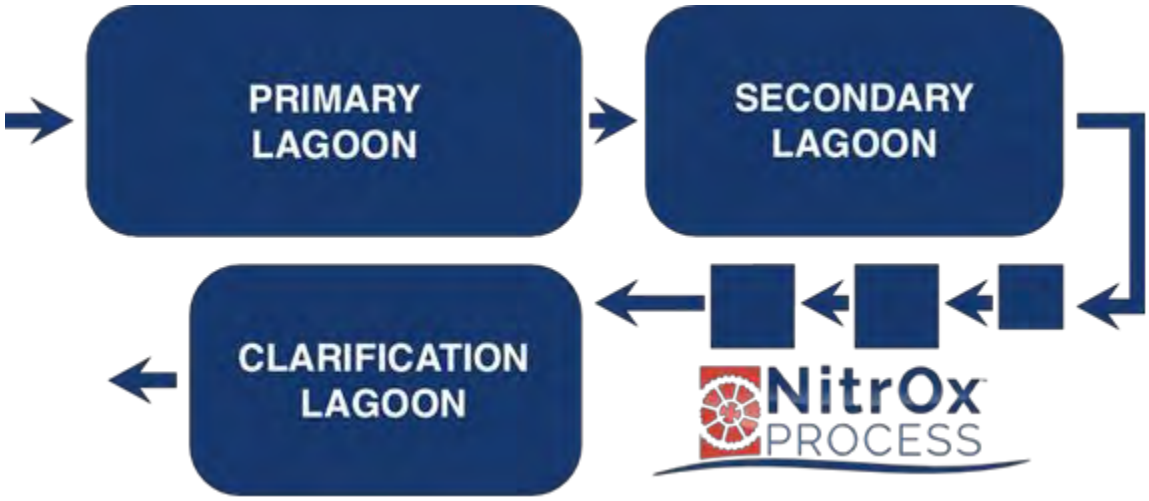

Figure 1: Basic flow process of the NitrOx Lagoon Ammonia Removal Process

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	Plant Influent Characteristics		
1	Average Daily Flow (Q)	1,670,000	gpd
2	Maximum Daily Flow	2,505,000	gpd
3	Peak Hourly Flow	3,674,000	
4	Influent BOD	408	mg/L
5	Influent BOD	5,683	lbs/day
6	Influent TSS	271	mg/L
7	Influent TSS	3,774	lbs/day
8	Influent NH3-N	35	mg/L
9	Influent NH3-N	487	lbs/day
10	Influent TKN	63	mg/L
11	Influent TKN	877	lbs/day
12	Influent pH	7	
13	Water Temperature	12	deg-C
	MBBR Influent Characteristics		
14	Average Daily Flow (Q)	1,670,000	gpd
15	Maximum Daily Flow (Assumes Equalization)	2,505,000	gpd
16	Influent BOD	59	mg/L
17	Influent TSS	59	mg/L
18	Influent NH3-N	14	mg/L
19	Influent TKN	14	mg/L
20	Design Influent TKN	14	mg/L
21	Design Influent NOx-N	33	mg/L
22	Influent pH	7	
23	Water Temperature	10.0	deg-C
	BOD/Nitrification Tank Sizing Summary		
24	No. of Tanks Proposed	3	
25	Length of Each	28.0	ft
26	Width of Each	28.0	ft
27	Side Water Depth of Each	17	ft
28	Tank Height of Each	20	ft
29	Volume of Each	99,693	gallons
30	Volume Total	299,080	gallons
31	Hydraulic Retention Time at Average Flow	4.3	hours
32	Hydraulic Retention Time at Peak Flow	2.9	hours

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	BOD/Nitrification MBBR Aeration Requirement Summary	Stage 1	Stage 2 & 3 (Combined)
35	AOR (lbs/day)	1,221	685
36	Assumed Diffuser Subm. at AWL (ft.)	16.25	16.25
37	Elevation (ft.)	4,459	4,459
38	Alpha	0.70	0.70
39	Beta	0.9	0.9
40	Target DO Residual (MBBR Process) (mg/L)	3.0	5.0
41	SOR (lbs/day)	3,294	2,779
42	Target Diffuser Efficiency/ft. Submergence	1.1	1.1
43	**Airflow (scfm)**	**731**	**617**
	Post-Anoxic Tank Sizing Summary		
44	No. of Tanks Proposed	1	
45	Width of Each	28	ft
	Length of Each	28	ft
46	Side Water Depth of Each	17	ft
47	Volume of Each	99,693	gallons
48	Volume Total	99,693	gallons
49	Hydraulic Retention Time	1.4	hours
50	Total Media Surface Area Requirement	97,776	m^2
51	Total Media Surface Area Proposed	98,125	m^3
	MBBR Blower Requirement Summary		
52	No. of Blowers	3	
53	Airflow Requirement per Blower	674	scfm
54	Airflow per 1,000 scfm	34	scfm/1,000 cf
55	Discharge Pressure	8.34	psig
56	Assumed Overall Efficiency	0.62	
57	Approximate BHP Requirement/Blower	47.3	bhp
58	Approximate BHP Requirement Total	94.6	bhp
59	Estimated Nameplate HP / Blower	50	hp
60	Blower Type	Tri-Lobe PD	
	Chemical Quantity Estimates		
61	Estimated MicroC per NOx-N Removed	11	lbs/lb.
62	Estimated MicroC Dosage	3,530	lbs/day
63	Estimated MicroC Dosage	365	gpd
64	Assumed Storage Tank Size (to Receive Bulk Truck)	5,500	gallons
65	Estimated HRT in Storage Tank	15	days
66	Estimated Chemical Feed Pump Max. Capacity Rqmt	30.4	gph
67	Estimated Chemical Feed Pump Min. Rt. Rqmt	3.8	gph

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Post-Denite MBBR Effluent Parameters (Downstream Solids Separation)

68	Effluent BOD	15	mg/L
69	Effluent BOD	208.9	lbs/day
70	Effluent TSS	20	mg/L
71	Effluent TSS	279	lbs/day
72	Effluent NH3-N	1.0	mg/L
73	Effluent NH3-N	13.9	lbs/day
74	Effluent TIN	11.0	mg/L
75	Effluent TIN	153.2	lbs/day
76	Effluent Total N	13.5	mg/L
77	Effluent Total N	188.0	lbs/day

---

1. $FTE = \alpha\ (SOTE)\ \theta^{(T-20)}\ (\beta\ C^*_{\infty T} - DO) \div C^*_{\infty 20}$ *field transfer efficiency*

   Where,

α	contaminant factor {contaminants, depth, bubble-size} (range: 0.40 – 0.70)
β	TDS factor {total dissolved solids} (range: 0.90-1.00)
$\theta = 1.024$	temperature factor
DO	target dissolved oxygen level (mg/L)
$C^*_{\infty T}$	saturation oxygen concentration at site – adjusted for water depth
$C^*_{\infty 20}$	sat. oxygen concentration at STP conditions – adjusted for water depth
T	water temperature (Celsius)

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NitrOx+D Budgetary Quote

Date: 3/13/2017
Project Name: Belgrade, MT
Project Number: 2672

QUOTE TO:

Nicole Rediske
TD&H Engineering

C/O: Ben Lewis
Ambiente H2O

PREPARED BY:

Tom Daugherty, Western Regional Manager
Triplepoint Environmental LLC

Phone: (208) 699-7090
Email: tomd@tpenv.com

NITROX+D™ NITRIFICATION EQUIPMENT COSTS

NitrOx+D Reactor System Equipment:

- Engineered to heat and treat an Average Daily Flow of 1,670,000 GPD.
- Capable of handling an Influent of NH3-N up to 35 mg/L and producing an Effluent of NH3-N at 1.0 mg/L, TIN at 11 mg/L, and Total N at 13.5 mg/L.
- **Total Cost: $1,140,420**

Standard NitrOx+D Package	Quantity	Unit
MBBR Tank Media: High Surface Area	4	SET
Aeration Grid: Stainless Steel	3	EA
Media Retention Sieves: Custom Welded	4	EA
Heat Exchanger & Boiler: Integrated	1	EA
Kaeser Blower EB291C 50HP: Duty	3	EA
Kaeser Blower EB291C 50HP: Standby	1	EA
Control Panel: NEMA 3R	1	EA
Carbon Feed Storage Tank: Micro-C Not Included	1	EA
Post Anoxic Tank Mixer	1	EA
NitrOx+D Tank Cover: Thermal Shield	4	EA

NOT Included: Optional Items

Real Time Monitoring: DO, NH3-N, pH, & Temperature Probe.....$18,160.00
(DO Probe Control with Blower VFD: Integrated)
Triplepoint Installation Supervision.....$3,600.00
Kaeser Blower Startup & Installation.....$2,000.00

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Thermal Regulation

The NitrOx+D Reactor will achieve nitrification at temperatures water temperatures as low as 4 degrees Centigrade. If the influent water temperature for the reactor is likely to dip below this level in the winter months, a thermal regulation system is necessary to regulate the water temperature in order to guarantee year-round nitrification.

Real Time Monitoring & Control System

An optional Real Time Monitoring System provides real-time monitoring of various parameters (including but not limited to BOD, COD, DO, NH3-N, pH, Temperature). Monitoring is completed with immersion probes—no reagents required. Telemetry capability can be incorporated such that real-time values can be viewed in remote locations, including via phone app.

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MARS Budgetary Quote

Date: 4/22/2017
Project Name: Belgrade, MT
Project Number: 2672

QUOTE TO:

Nicole Rediske
TD&H Engineering

C/O:
Ben Lewis
Ambiente H2O

PREPARED BY:

Tom Daugherty, Western Regional Manager
Triplepoint Environmental LLC

Phone: (208) 699-7090
Email: tomd@tpenv.com

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Triplepoint Installation Supervision……$3,600.00
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Baffle Curtain: 6730 RX-5……(To Be Determined)

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MARS™ AERATION EQUIPMENT COSTS

MARS AERATOR System Equipment: Post NitrOx

- Designed to mitigate odors in storage lagoon after the NitrOx.
- **Total Cost: $134,970**

MARS Aeration Package: Nitrification	Quantity	Unit
MARS 750T Aerators with EPDM Membranes	30	SET
1.5'' Barbed Fittings: Stainless Steel	30	EA
1.5" Weighted Flexible Tubing	2500	LF
1.5" Full Port Ball Valve & Fittings: Stainless Steel	30	EA
8 Port Stainless Steel Manifolds (2 caps)	4	EA

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NitrOx Annual Opperating Costs

Date: 4/12/17
Project Name: Belgrade, MT
Project Number: 2672

NitrOx Aeration with Kaeser Blower		
Pressure	8.34	psi
Brake horsepower	94.6	bhp
Motor Efficiency	95%	
Cost per Kwh	$0.09	
Power Consumed	**74.68**	**kW**
Hourly Cost	$6.72	/hr
Daily Cost	$161.32	/day
Monthly Cost	$4,908.90	/mon
Annual Cost	**$58,906.84**	**/yr**

[1] This is the total rated hp from the info plates mounted on all motors.
[2] This is what percent of the maximum rated horsepower, the motors are running at. Normally this should be 75-80%. If the motors are constantly burning out, use 95-105%.

Note: All costs are in United States Dollars

NitrOx MicroC Dosage		
Estimated MicroC Dosage	365	**GPD**
Estimated MicroC Dosage	3,530	**lbs/Day**
Estimated MicroC Feed	3.8	**GPH**
Price Per MicroC Gallon	$2.10	**Gallon**
Price Per Day	$766.50	**Day**
Price Per Year	$279,772.50	**Year**

Note: All costs are in United States Dollars

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Natural Gas NitrOx Heating Cost Calculation			
Gallons Per Day		1,670,000.00	gpd
Gallons Per Hour	Q =	69583	gph
Water density	ρ =	8.34	lb/gal
Water mass flow W = W*ρ	W =	**580,322**	lb/hr
Final temperature	T2 =	41	°F
Initial temperature	T1 =	37	°F
Temperature rise ΔT = T2 - T1	ΔT	**4**	°F
Energy required Eh = W*ΔT	Eh =	**2,321,288**	Btu/hr
Energy Required/day Ed = Eh*24	Ed =	**55,710,912**	Btu/day
Energy required/week Ew = Eh*24*7	Ew =	**389,976,384**	Btu/week
HX efficiency	e =	83.00%	
Efficiency adjustment Ed' = Ed/e	Ed' =	**67,121,581**	Btu/day
Efficiency adjustment Ew' = Ew/e	Ew' =	**469,851,065**	Btu/week
Therms/day Th = Ed'/100000	Th =	**671.22**	Therms/day
Therms/week Th = Ew'/100000	Th =	**4,698.51**	Therms/week
Cost Per Therm		**$1.10**	$/Therm
Cost C = Th*1.1	C =	**$738.34**	/day
Cost C = Th*1.1	C =	**$5,168.36**	/week
Cost C = Th*1.1	C =	**$22,519.37**	/month
Cost C = Th*1.1	C =	**$270,232.44**	/year

Note: This pricing assumes $1.10/100,000 BTU. Heating of the NitrOx System is only required when temperature drops below 4C. All heating costs are calculated at heating the water up to a conservative 5C°, instead of the required 4C°.

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Nicole Rediske - RE: FW: Belgrade, MT Wastewater Lagoons Design Conditions (B16-048)

From: Tom Birkeland <TBirkeland@lemna.com>
To: Nicole Rediske <Nicole.Rediske@tdhengineering.com>
Date: 4/7/2017 10:34 AM
Subject: RE: FW: Belgrade, MT Wastewater Lagoons Design Conditions (B16-048)
Attachments: Upflow Sand Filter.pdf

Nicole,

Thanks for getting back to me. Please see the answers below in red. Let me know if you need any other information. Best regards,

Tom Birkeland
Lemna Environmental Technologies
O: (612) 253-1968 / C: (612) 616-8392 / E: tbirkeland@lemna.com

From: Nicole Rediske [Nicole.Rediske@tdhengineering.com]
Sent: Thursday, April 06, 2017 2:48 PM
To: Tom Birkeland
Subject: RE: FW: Belgrade, MT Wastewater Lagoons Design Conditions (B16-048)

Good Afternoon Tom,

I have been looking through the information you sent over and was hoping you could clarify something for me:

- are the diffusers in the complete mix cell and settling cell the same fine bubble diffusers? The two types of diffusers are essentially the same- of the flexible membrane tube type. The difference is in their lengths. The high rate diffusers are 4' long and supply 18 SCFM, while the low-rate diffusers are 2' long and supply 9 SCFM.
- I just wanted to make sure no biological or chemical additives would be required for the LPR. This is correct. The bacteria naturally establish colonies on the surface of the fixed film reactor without any chemical or biological additives.
- For the denitrification filters, is there any brochures or literature you could forward on to me? I have attached some diagrams of the filter. A description is below:

"The upflow, gravity filter is a moving bed design that provides a continuous supply of filtered water without the interruptions of backwash cleaning cycles. Influent enters the center of the filter through a feed chamber and flows downward through the central feed chamber and radial arm system. Filtered water is collected in the effluent nozzle located at the top of the filter cell after passing through a minimum of 80 inches of filter media.

Solids captured in the filter bed are drawn downward with the sand into the suction of an airlift pump. The turbulent, upward flow in the airlift provides a scrubbing action that effectively separates the sand and solids before discharging into the filter washbox. The washbox is a baffled chamber that allows for gravity

separation of the cleaned sand and the concentrated waste solids. This process is accomplished by utilizing filtrate water to clean the contaminated sand. From here, the regenerated sand is returned to the top of the filter bed, and the solids, or "reject", are piped to a suitable disposal point."

- . is the carbon needed for the filter available through LEMNA and is it included in the $1.2 million estimate I did not include the cost of the chemical feed equipment in the $1.2 million estimate. I think that this would add on another $50-60K. The carbon source would also be additional. There are many alternatives available including MicroC and methanol.

- do you have an idea on how often the filters will need to be replaced? If operated and maintained properly, the media in the sand filters should not need to be replaced.

Thank you for all of your help on this. I apologize for taking so long to get back to you with my questions.

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

>>> Tom Birkeland <TBirkeland@lemna.com> 3/20/2017 10:32 AM >>>

Nicole,

Just following up with you regarding the TN solution for Belgrade, MT.

As per my previous email, our proposed design utilizes one of the existing lagoons to handle a total design flow of 1.67 MGD. Following the treatment lagoon, a Lemna Polishing Reactor (LPR) will provide additional BOD removal and ammonia treatment. Denitrification would be accomplished via carbon addition and filtration through media filters after the LPR. The media filters have an approximate footprint of 10' x 10', and a total of 6 would be required for this project. The cost of the filters is approximately $1,200,000.

One of the benefits to this approach is that it maintains the simple, flow through process of a lagoon system in place. I will follow-up with you today to see if you require any other additional information.

Best regards,

Tom Birkeland
Lemna Environmental Technologies
O: (612) 253-1968 / C: (612) 616-8392 / E: tbirkeland@lemna.com

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From: Nicole Rediske [mailto:Nicole.Rediske@tdhengineering.com]
Sent: Thursday, February 23, 2017 11:18 AM
To: Tom Birkeland
Cc: scott@chcwater.com; Camille Johnson; Dustin Nett; Wade DeBoo
Subject: RE: FW: Belgrade, MT Wastewater Lagoons Design Conditions (B16-048)

Hello Tom,

Thank you for getting that proposal to me.

I see that the treatment system is very efficient at removing ammonia from the wastewater, does much denitrification occur to remove the nitrates? The City's discharge permit sets limits on total nitrogen loading to each of the IP Beds. Any upgrades to the City's treatment system will need to maintain total nitrogen concentrations of 13.5 mg/l in the effluent.

I was also wondering if a headworks facility will be required for this system? Currently the City does not have one but we are considering including one in suggested upgrades.

Finally, any information you can provide on the following would be very helpful:

- Details regarding the Polishing Reactor including cut sheets, maintenance information, ect.
- Projected power consumption at a range of flow rates under the design flow rate
- Maintenance information for the aeration system
- Details on the blowers including size and air requirements

Thanks again for all of your help. Please let me know if you have any questions.

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

>>> Tom Birkeland <TBirkeland@lemna.com> 1/25/2017 10:48 AM >>>
Nicole,

Please find the attached proposal and design drawing for the Belgrade Lagoon Project. We are upgrading the aeration in one of the existing lagoons and adding our polishing reactor on the backend to achieve the performance requirements.

Once you have had a chance to review the proposal and design, please feel free to contact me with any questions or for more detail regarding our process design. Thanks again for contacting us regarding this opportunity and best regards,

Tom Birkeland
Lemna Environmental Technologies
O: (612) 253-1968 / C: (612) 616-8392 / E: tbirkeland@lemna.com

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From: Nicole Rediske [mailto:Nicole.Rediske@tdhengineering.com]
Sent: Tuesday, January 10, 2017 11:00 AM
To: Tom Birkeland
Cc: scott@chcwater.com
Subject: Re: FW: Belgrade, MT Wastewater Lagoons Design Conditions (B16-048)

Tom,

I have attached all the pond inflow/outflow data that I currently have. There is a period between March 2011 and Oct 2013 that I am still trying to get my hands on. Also, the operators try to keep the DO concentration around 2 mg/l within the treatment ponds.

The construction of the existing ponds finished up in July 2004.

And lastly, I misspoke yesterday, the treatment ponds have static tube aerators, not the fine bubble diffusers. The storage lagoon does have the surface aerators still.

Thank you and let me know if you have any further questions.

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

>>> Tom Birkeland <TBirkeland@lemna.com> 1/9/2017 10:33 AM >>>
Nicole,

Thanks for taking the time to speak with me today regarding the Belgrade project. If you could send over any effluent data you have on the system that would help us assess current and future performance of the lagoons.

The treatment lagoons are aerated with a fine bubble diffuser system, while the settling pond has surface aerators.

Also, as we discussed the current permit allows for a maximum of 72-74 pound per day of N for each of the individual IP beds. This number may change with the new permit.

We will take these factors along with the influent data you sent over when we propose possible upgrades to the system.

Thanks and best regards,

Tom Birkeland
Lemna Environmental Technologies
O: (612) 253-1968 / C: (612) 616-8392 / E: tbirkeland@lemna.com

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From: Scott Forsling [mailto:scott@chcwater.com]
Sent: Friday, January 06, 2017 5:04 PM
To: Tom Birkeland
Subject: Fwd: Belgrade, MT Wastewater Lagoons Design Conditions (B16-048)

Hi Tom—

Please see below from TD&H for Belgrade, MT.

Thanks,

Scott Forsling, PE
Coombs Hopkins Company
435-659-7199
scott@chcwater.com

Begin forwarded message:

From: Nicole Rediske <Nicole.Rediske@tdhengineering.com>
Subject: Belgrade, MT Wastewater Lagoons Design Conditions (B16-048)
Date: January 6, 2017 at 3:34:33 PM MST

To: <scott@chcwater.com>
Cc: Camille Johnson <Camille.Johnson@tdhengineering.com>, Dustin Nett <Dustin.Nett@tdhengineering.com>, Wade DeBoo <Wade.DeBoo@tdhengineering.com>

Good Afternoon Scott,

I met with you about a month ago in Great Falls, MT and discussed LEMNA's aerated lagoons. TD&H is currently working with the City of Belgrade on a Wastewater Master Plan. Part of that Master Plan will be evaluating the current treatment lagoons and assessing possible improvements. I was hoping you would be able to provide me with an estimate for LEMNA's aerated lagoon system's performance with the following design conditions:

- This is a municipal system that does not take in any industrial waste
- Currently there are three ponds, 2 treatment ponds and 1 pond
    - Ponds 1 & 2 (treatment ponds)
        - Aerated Lagoons
        - Water surface area is about 7 acres each. (554' x 550')
        - Operating depth is 10 feet in both
        - Each has a volume of about 16 MG
        - Sides slopes are 4:1
        - 7 feet of free board
    - Pond 3 (storage pond)
        - Water surface area is about 15.8 acres (580' X 1185')
        - Operating depth is 19.25 feet
        - Volume is 81.5 MG
        - Side slopes are 3:1
        - 3 feet of free board
    - If at all possible, we would like to keep the same footprint
- Design flows
    - Average day=1.67 MG
    - Peaking factor=2.7
    - Peak hour flow=4.51 MG
- Influent wastewater data
    - I have attached monthly concentration data for the influent wastewater from Nov 2013 to Dec 2016. The average concentrations are listed below:
        - Ammonia (as N) = 34.3 mg/l
        - Total Nitrogen = 63.5 mg/l
        - BOD = 407.7 mg/l

    - TSS= 271.3 mg/l
    - Nitrates + Nitrites (as N)= 0.5 mg/l
    - TKN (as N)=63.0 mg/l

- Currently the lagoons discharge to three IP beds and an irrigation system
- Treatment requirements

    - 85% TSS and BOD removal
    - The current groundwater discharge permit sets limits on total nitrogen loading to each IP bed and TN concentrations are the end of the mixing zone.

I am most an LEMcurious about the amount of nitrogen removal NA system could achieve.

Please do not hesitate to contact me and 406-761-3010 if you have any questions or need additional information.

Thank you and Happy New Year.

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

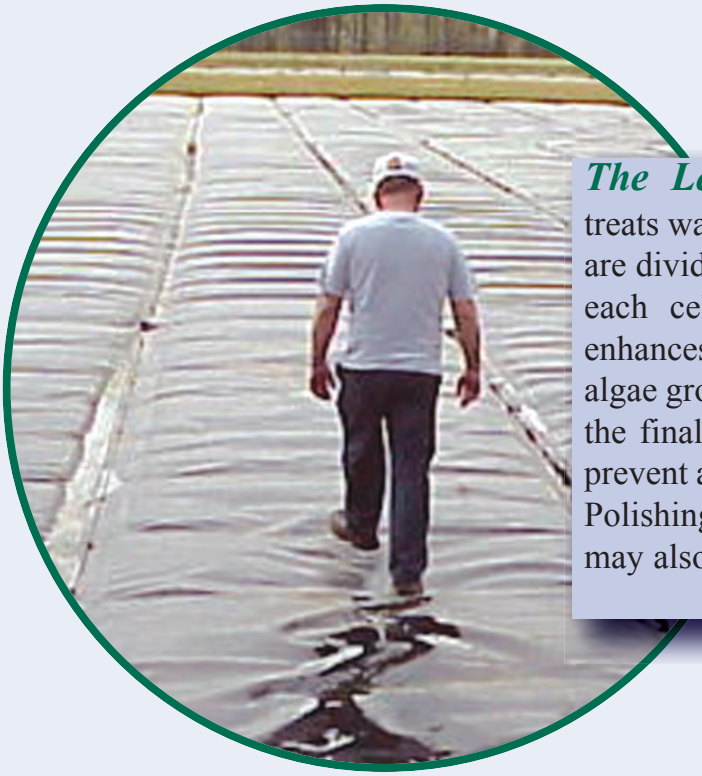
LemTec™ Process

LEMNA TECHNOLOGIES, INC.

Municipal and Industrial Treatment

Innovative Wastewater Solutions

The Leader In Lagoon Process Technology



The LemTec™ Biological Treatment Process (LBTP) treats wastewater as it flows through a series of aerated lagoons that are divided by baffles to reduce short-circuiting. In colder climates, each cell is covered by a LemTec™ Modular Cover, which enhances system kinetics, retains heat, controls odors, and prevents algae growth. In warmer climates, it may be necessary to cover only the final settling cell in order to promote digestion of sludge and prevent algae growth. Additional technologies, including the Lemna Polishing Reactor and the Lemna Phosphorus Removal System, may also be used for enhanced nutrient removal.

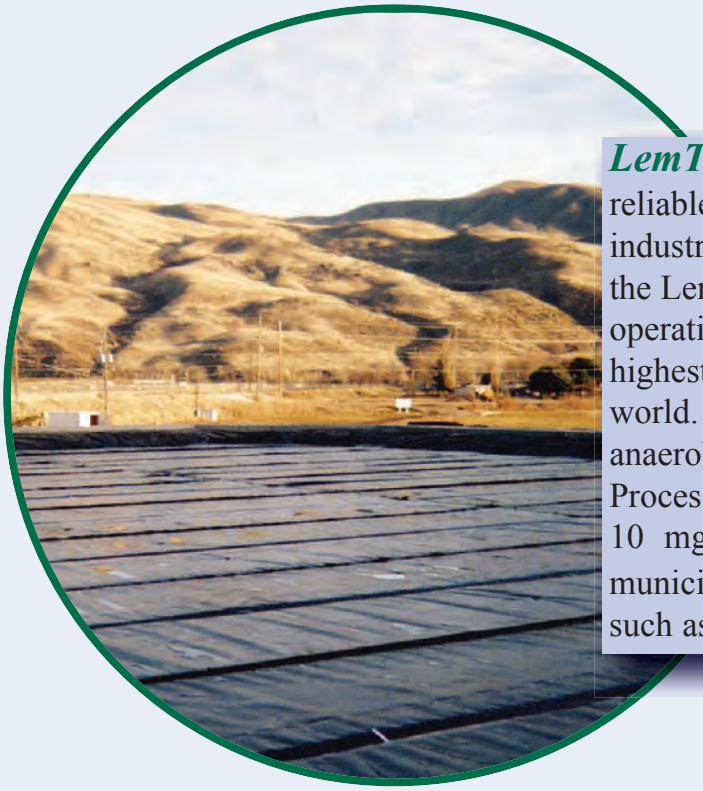
Customer satisfaction is our highest priority . . .

"The installation went very well, and the performance of the system has been excellent. We have been within our discharge limits since the installation, and have been more than satisfied with the performance of this system. I would most certainly recommend the Lemna system to other municipalities which use oxidation ponds and find themselves having problems with discharge limits." ***Operator - R.D., Louisiana***

"Lemna is definitely a leader rather than a follower. In addition, the LemTec™ Biological Treatment Process has over the last two years proven to be an excellent choice. The installation process is simple yet effective in its high degree performance and low maintenance cost." ***Client - B.L., New Hampshire***

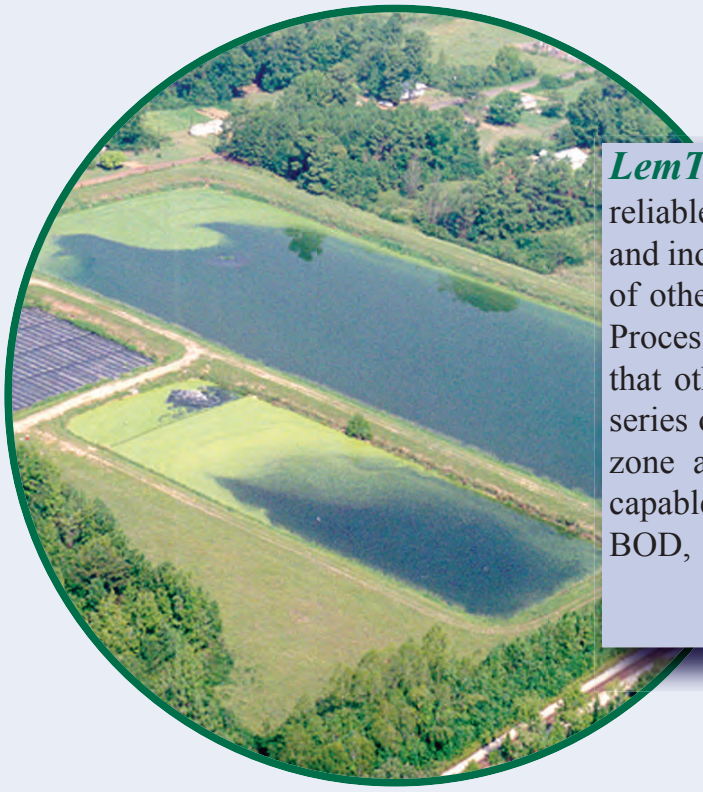
"It has been a pleasure to work with Lemna Technologies. The service and support is fast and friendly." ***Client - P.V., Wisconsin***

LemTec™ Process Family



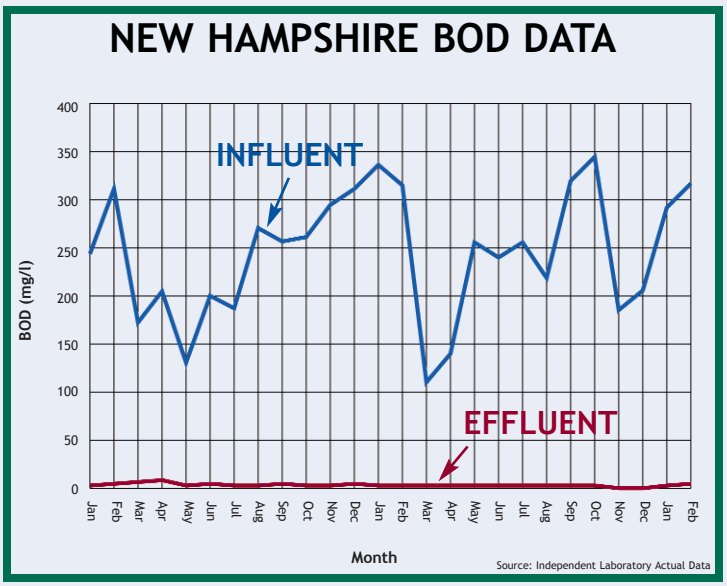
LemTec™ Biological Treatment Process is an effective, reliable and affordable solution for existing aerated municipal and industrial wastewater lagoon facilities. The system incorporates the LemTec™ Modular Cover to create a reduced footprint and an operation that is virtually odor-free. The LemTec™ system is the highest performing pond-based aerated lagoon process in the world. Utilizing a series of aerobic treatment cells followed by an anaerobic settling zone and polishing reactor, the LemTec™ Process is capable of achieving year-round effluent limits as low as 10 mg/l BOD, 15 mg/l TSS and 2 mg/l NH_3-N for typical municipal or pre-treated industrial wastewater. Other nutrients such as Phosphorus can also be addressed within the process.

Existing Lagoons or New Construction

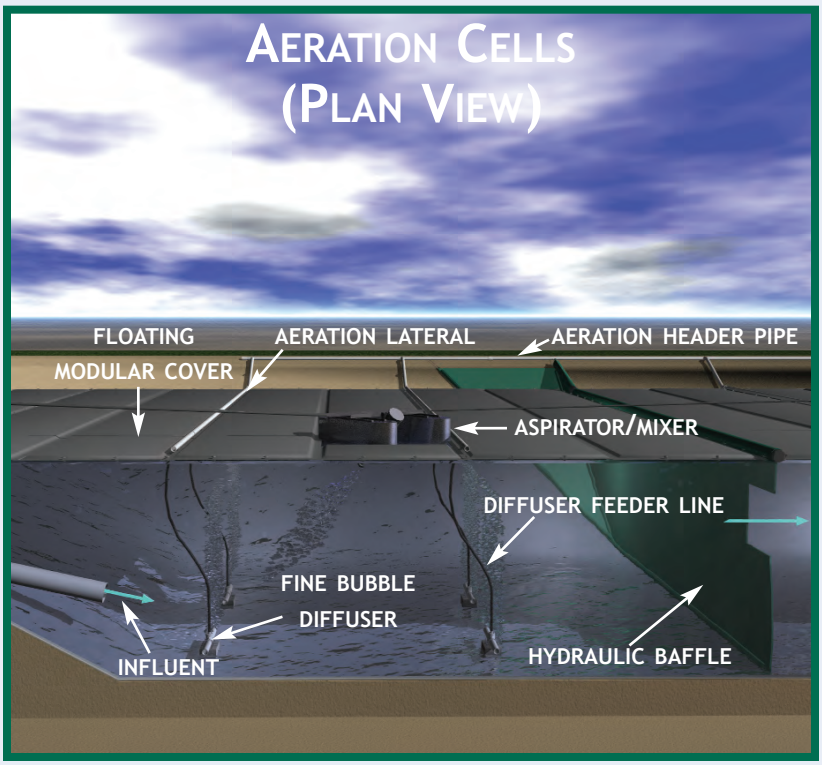


LemTec™ Facultative Treatment Process is an effective, reliable and affordable solution for existing facultative municipal and industrial wastewater lagoon facilities. At a fraction of the cost of other traditional systems, the LemTec™ Facultative Treatment Process is unmatched in its ability to meet stringent effluent limits that other traditional pond-based systems can't reach. Utilizing a series of facultative treatment cells followed by a covered settling zone and Lemna Polishing Reactor, the LemTec™ Process is capable of achieving year-round effluent limits as low as 10 mg/l BOD, 15 mg/l TSS and 2 mg/l NH_3-N.

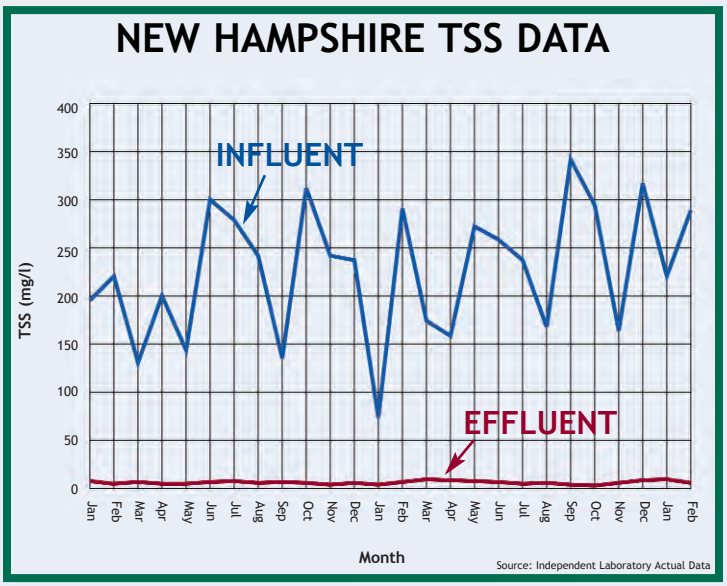
BOD Removal



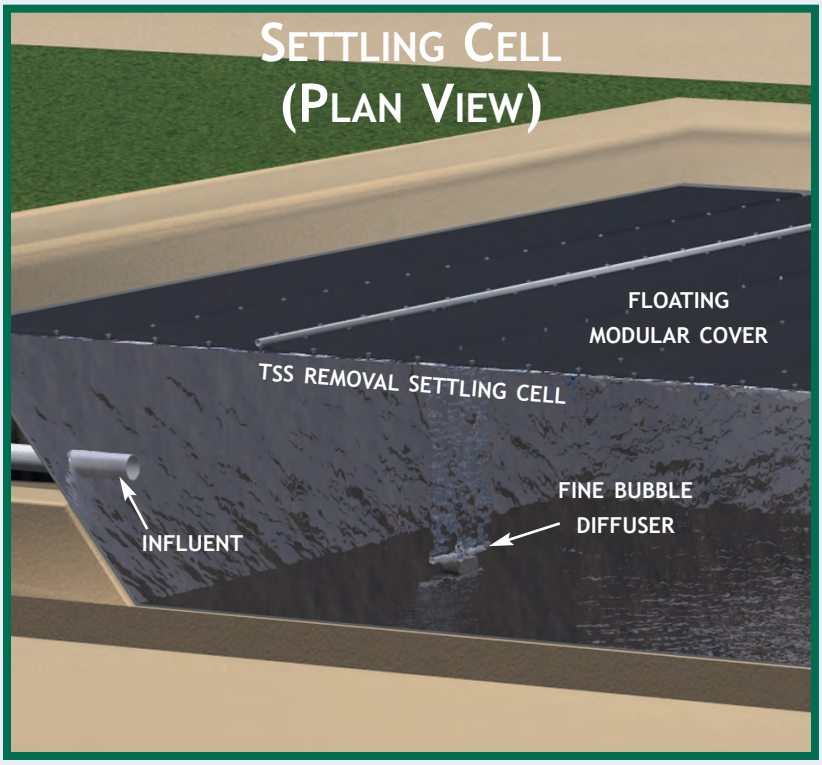
Achieving BOD levels below 10 mg/l reliably and consistently throughout the year. BOD removal to below 30 mg/l is accomplished in the complete mix and partial mix cells of the treatment process with final polishing to below 10 mg/l in the Lemna Polishing Reactor, if required. Lemna's design minimizes temperature fluctuations and the adverse treatment effects of peak flow events on BOD removal. Our low horsepower design is efficient in both aeration and mixing and requires a smaller footprint that is typically 12 days or less in detention time.



TSS Removal



Lemna's settling cell - a clarifier without the moving parts. The settling pond, covered with the LemTec™ Modular Cover, creates an effective zone for clarification of biosolids. The cover prevents algae growth by eliminating sunlight and improves clarification in two ways: 1) it prevents wind action on the water surface, thereby establishing a quiescent zone for solids to settle; and 2) the insulation minimizes seasonal and diurnal temperature fluctuation thereby reducing stirring by thermal currents. In addition, the anaerobic environment in the settling pond digests the biosolids significantly over time with no sludge disposal required for at least 5 to 7 years.

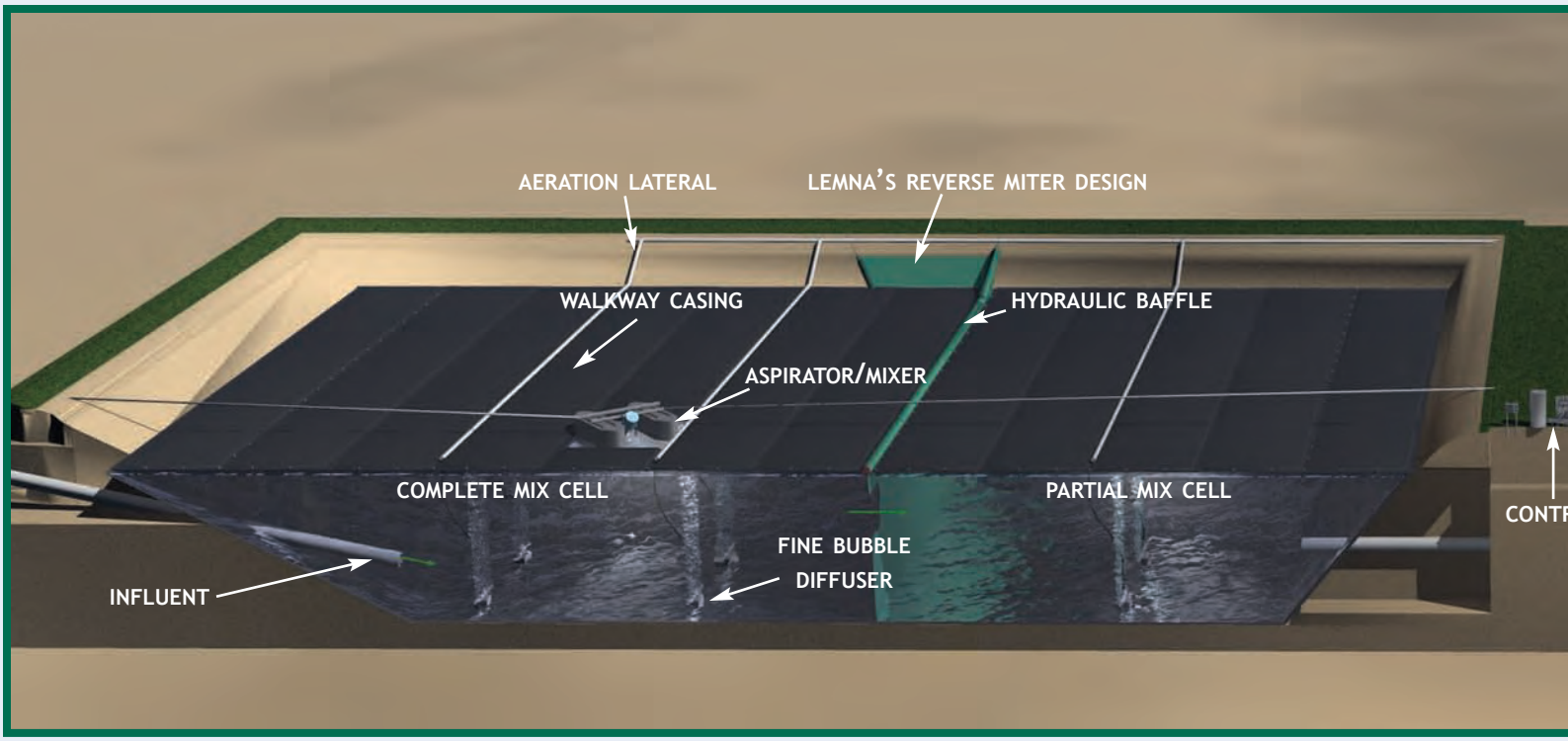


The LemTec™ Biologic

"We have done numerous projects over the last five years using Lemna Technologies Inc., and I highly recommend this company. They are very proficient, have excellent take-offs, detailed instructions, the product is easy to install and their supervisors are knowledgeable and skilled. We look forward to the next opportunity to work with them." ***Contractor - T.S., Louisiana***

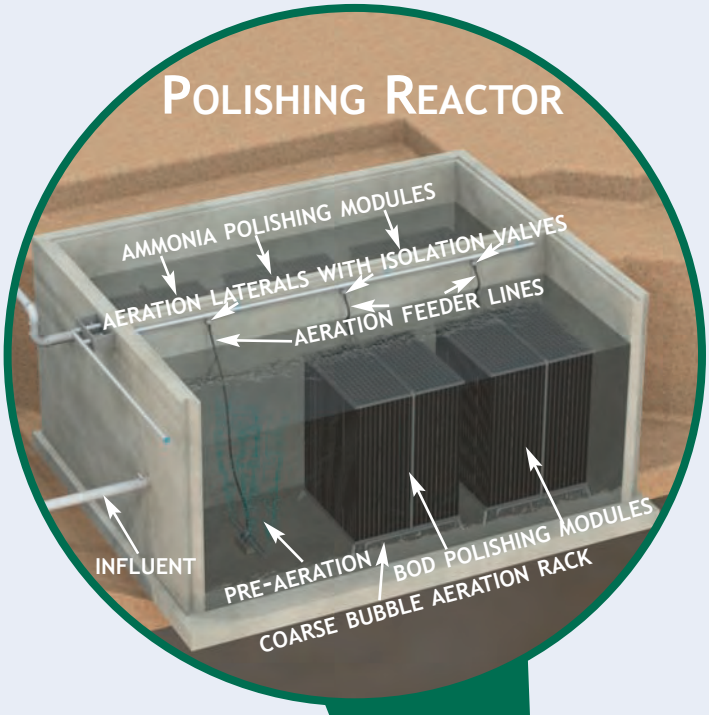
"Since installation, we have noticed excellent odor control, algae control, and our effluent test levels are remarkable. To encourage the choice of Lemna Technologies products, we welcome anyone interested to tour our facilities and/or review our weekly test results." ***Client - J.R., Iowa***

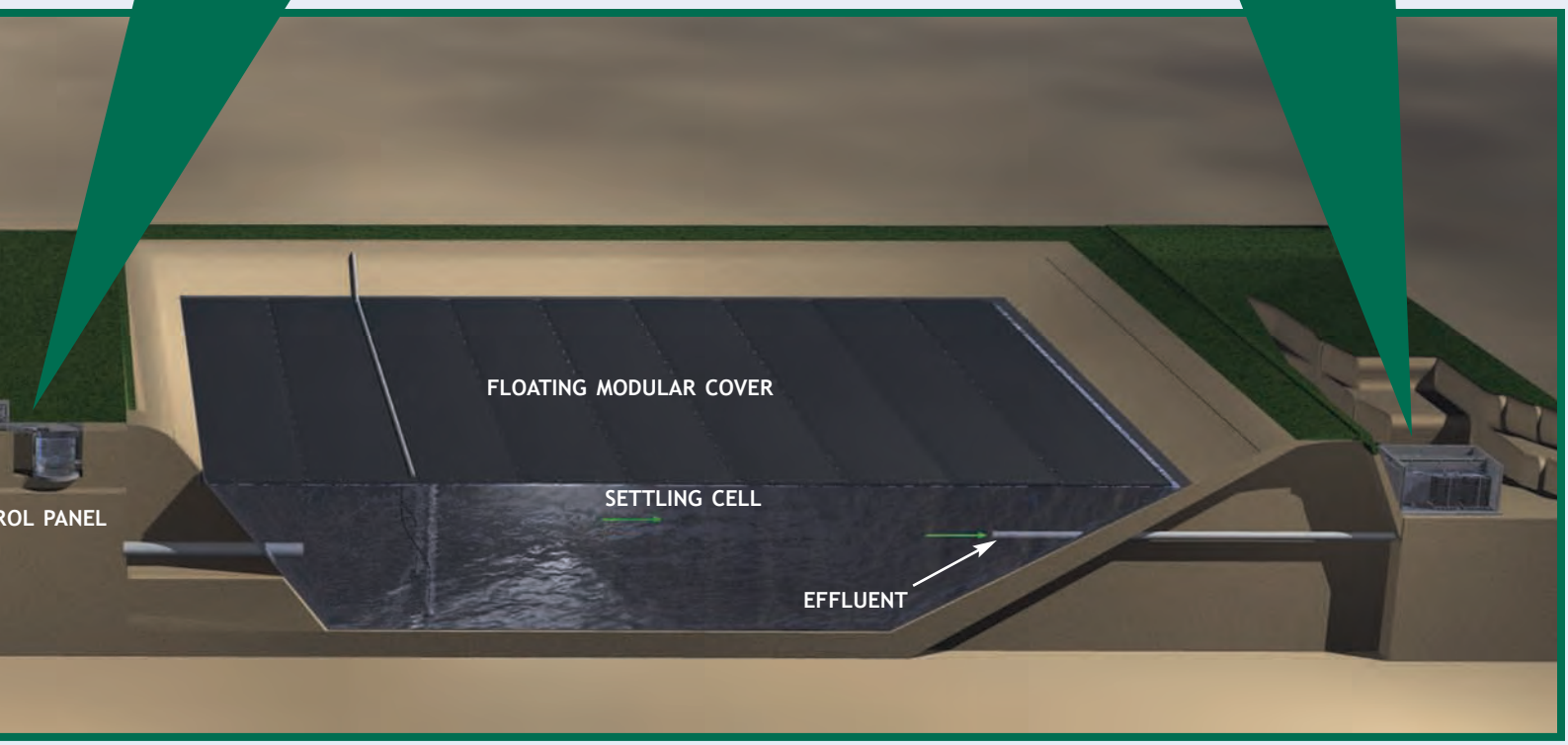
Lemna's cover and staff have provided performance as promised. Anytime we've had questions related to technical support, Lemna has been prompt in their response. I can safely state that maintenance on our cover has been virtually non-existent, and I highly recommend Lemna for anyone considering them for a cover or liner." ***Client - R.L., Minnesota***



Custom-designed to me

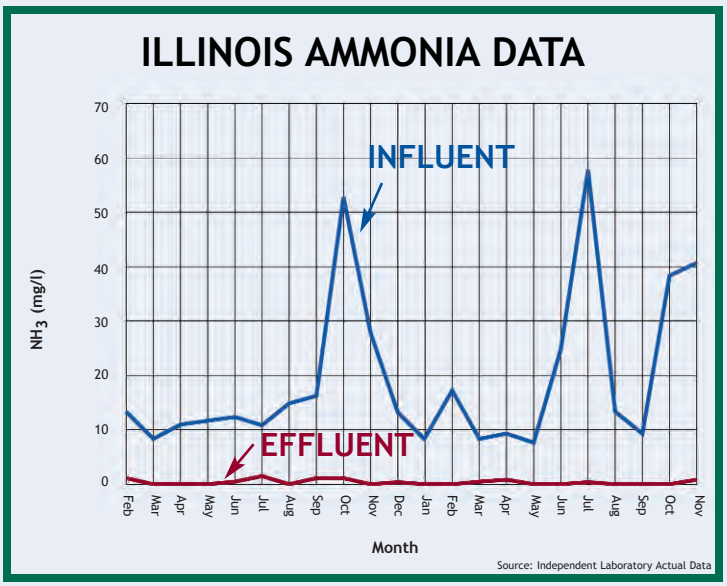
CAL TREATMENT PROCESS



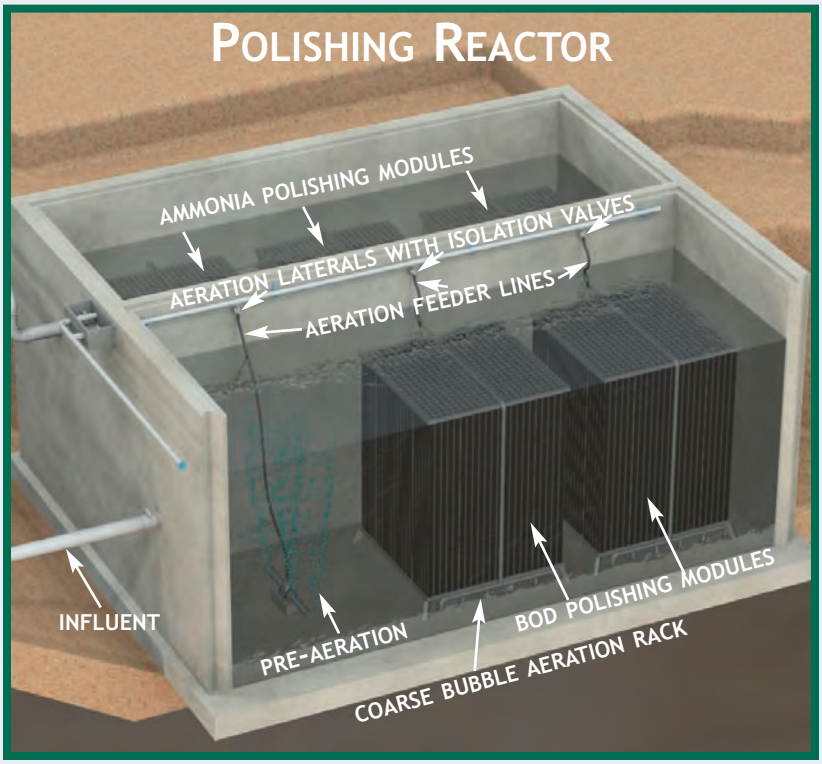


ET YOUR SPECIFIC NEEDS!

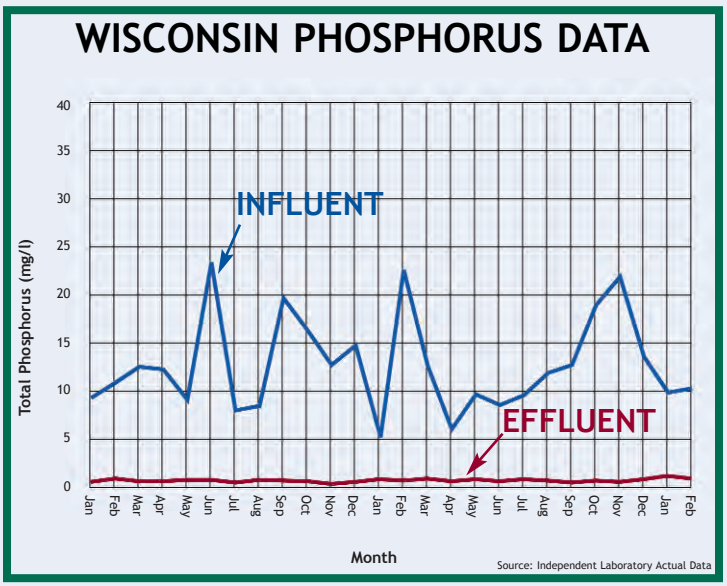
Ammonia Removal



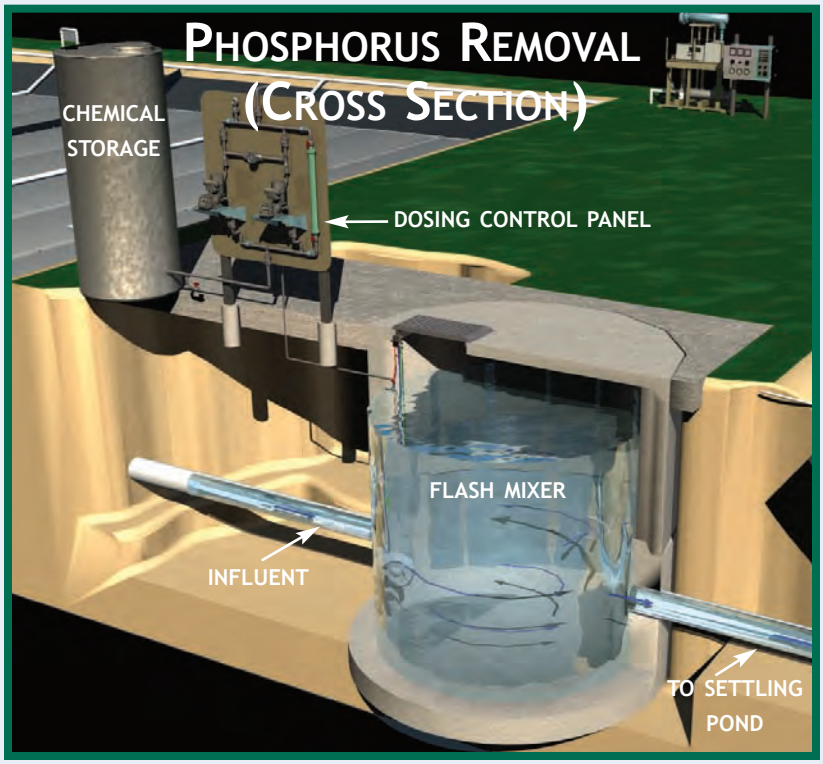
The Lemna Polishing Reactor (LPR) reduces Ammonia Nitrogen (NH_3-N) and BOD. The majority of both BOD and Ammonia removal in the Lemna design occurs in the complete mix cell. However, the LPR is included in the LBTP design to meet low BOD_5 (<10 mg/l) and NH_3 (<1 mg/l) limits if required. The LPR utilizes fixed media to promote an environment for submerged attached-growth bacteria. The LPR is composed of stainless steel hardware and frames that compress UV resistant PVC media, making the reactor sturdy and one of the best filters in the industry.



Phosphorus Removal



We use a chemical dosing system, low horsepower pumps and mixers that make operation easy. Phosphorus is precipitated chemically by the addition of coagulants, including alum or ferric chloride. Precipitation causes contaminants that are either dissolved or suspended to settle out of solution as solid floc particles that are removed along with waste biological sludge. Our system is low cost and reliable.

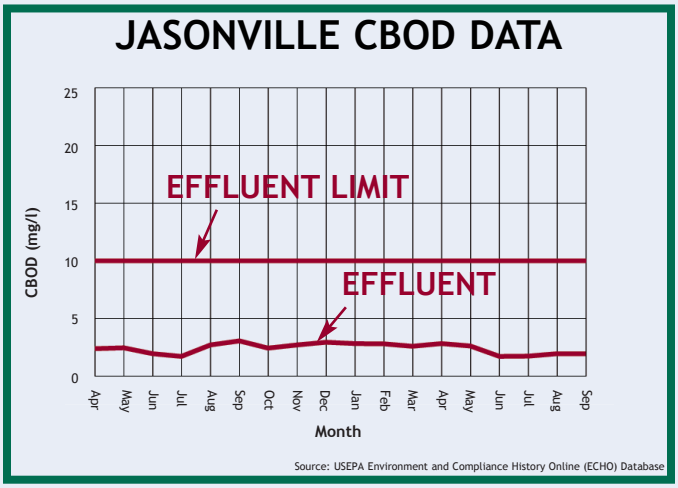


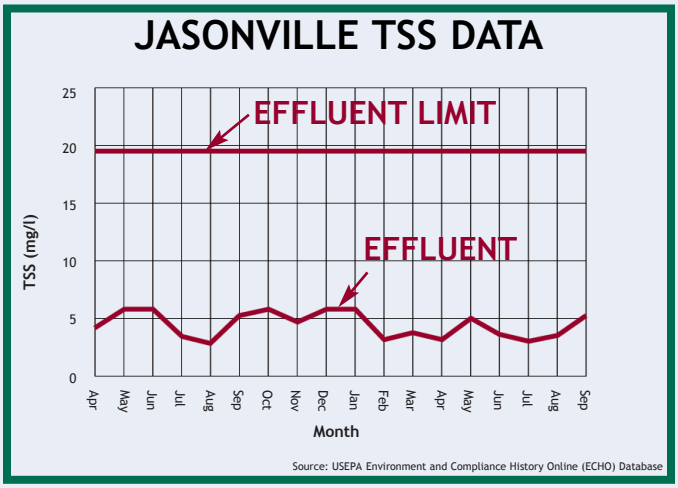
Case History

Aerated lagoon upgrades

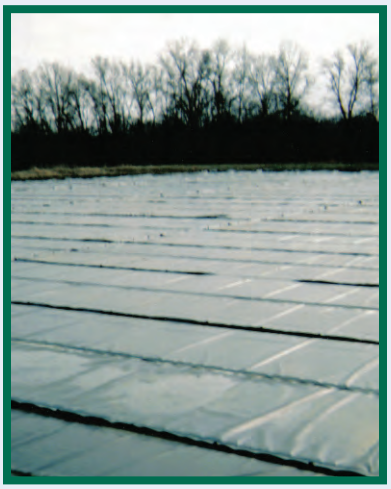
Case Study: Jasonville, Indiana

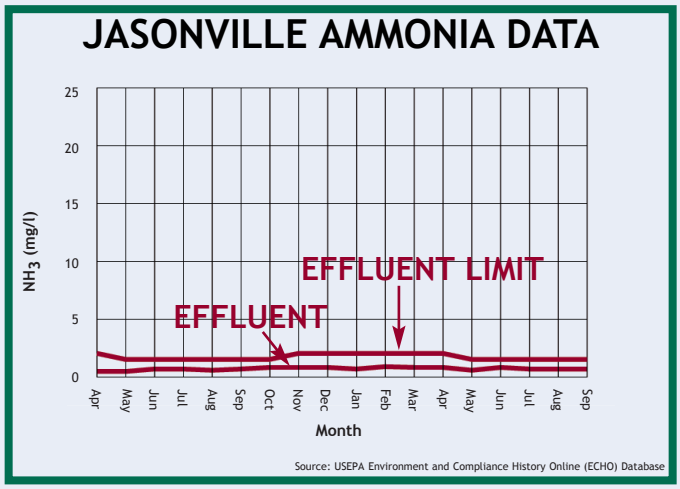
Project Background: The wastewater treatment plant, located in Jasonville, Indiana, was an existing lagoon system that no longer performed to the new environmental regulations for Ammonia. The Ammonia removal process, which is difficult in any wastewater treatment system, is especially complex in cold weather climates like Jasonville.





This system was designed to incorporate the existing lagoons and aeration equipment to create the most cost effective system. There were two existing large wastewater treatment ponds. The entire first pond was incorporated into this design and half of the second pond was used by constructing a berm in that pond. The aeration pond has a detention time of 15.8 days. The aeration cell is partially mixed. New diffused aeration was added to supplement the existing aeration. The third cell is a settling cell with a detention time of 7.4 days. The settling pond is followed by a Lemna Polishing Reactor (LPR) consisting of sixteen media modules for effluent polishing.





Site Performance: The Jasonville facility provides reliable removal of CBOD, TSS and Ammonia over a wide range of operating conditions including high flows, cold operating temperatures and variable loads.

FEATURES AND BENEFITS

Easy to Operate

- Minimal operator requirements
- No complicated sludge handling
- No solids return/recycle
- Start-up and operator training provided

Flexible Designs

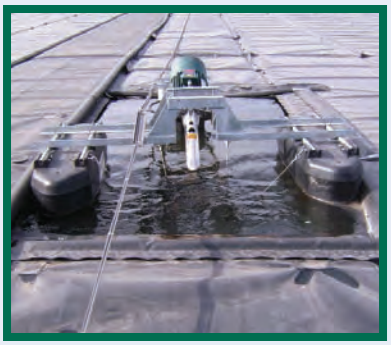
- New or existing lagoons
- Reliable at high or low flows
- Easy to expand for future flows
- Designs for any climate

Affordable

- Small footprint and land required
- Minimal HP required
- Low operator costs
- Simple construction

Proven Technology

- 25 years of experience
- The leader in lagoon nitrification
- Dedicated to the environment



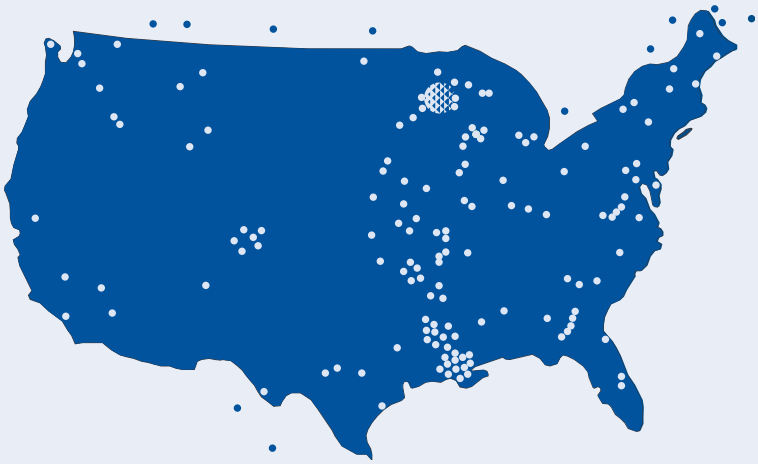
"The city purchased a turn-key wastewater treatment facility over 20 years ago. I would recommend Lemna to any community or industry in need of water treatment." ***Client - J.M., North Dakota***

Wastewater Treatment Experts

Lemna has been the world leader for more than 25 years in high-performance lagoon-based wastewater treatment technologies. We have 100's of treatment facilities with installations on four continents.

Headquartered in Minneapolis, Minnesota, Lemna designs and installs systems for all municipal and industrial applications. Lemna provides a full range of wastewater design and engineering services, backed by exceptional results and customer service.

"LEMNA PROVIDES A SIMPLE SOLUTION FOR WASTEWATER TREATMENT PROBLEMS"



Lemna Technologies, Inc.
2445 Park Avenue
Minneapolis, Minnesota, U.S.A. 55404-3790
Phone: (612) 253-2002
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www.lemnatechnologies.com

Lemna Technologies, Inc. **Engineering** **Belgrade, MT**
Rev. 0 1/17/2017

Wastewater Data	Summer	Winter		Summer	Winter		Site Data		
Flow	1.67	1.67	MGD				Winter Air Temperature	23	°F
BOD	408	408	mg/L	30	30	mg/L	Winter Air Temperature	-5.0	°C
TSS	272	272	mg/L	30	30	mg/L	Elevation	4459	ft AMSL
Ammonia	63	63	mg/L	2.0	2.0	mg/L	Atmospheric Pressure	12.5	psia
Total Nitrogen	-	-		-	-	mg/L	Distance to Site	1003	miles
Phosphorus	-	-	mg/L	-	-	mg/L			

Basin # 1

Included?	yes	
Influent Temperature	10.0	°C
Flow	1.7	MGD
Covered?	yes	
Water Depth	10.0	ft
Freeboard	7.0	ft
Slope	4.0	to 1
Length (waterline)	554	ft
Width (waterline)	550	ft
Length (bottom)	474	ft
Width (bottom)	470	ft
Length (at top of berm)	610	ft
Width (at top of berm)	606	ft
Cover Area	304,700	sf
Floor Area	222,780	sf
Volume	2,606,697	cf
Volume	19.5	MG
Detention Time	11.7	days
Selected R (Nominal)	8.0	°F·hr·sqft/BTU
Delta T	1.89	°F
Heat Loss Rate	1,099,593	BTU/hr
Heat Balance Convergence	0.0	
Water Temperature	48.1	°F
Covered Basin Temp.	**8.9**	°C
Uncovered Basin Temp.	**0.0**	°C

Cell Sizing

Cell	Mixing	Det Time (d)	Depth (ft)	Winter Temp.	Rate (d^{-1})	$CBOD_5$ In	$CBOD_5$ Out	NH_3 In	NH_3 Out	Nitrification?
1A	CM	4.2	10.0	9.6	4.5	408	12	63	46	no
1B	SC	7.5	10.0	8.9		12	12	46	46	no

Cell	Mixing	Det Time (d)	Depth (ft)	Summer Temp	Rate (d^{-1})	$CBOD_5$ In	$CBOD_5$ Out	NH_3 In	NH_3 Out	Nitrification?
1A	CM	4.2	10.0	20.0	6.0	408	11	63	0.6	yes
1B	SC	7.5	10.0	20.0		11	11	0.6	0.6	no

Aeration and Mixing Requirements

Cell	Mixing	$CBOD_5$ (lb/d)	NH_3 (lb/d)	$CBOD_5$ (SCFM)	NH_3 (SCFM)	Mixing (SCFM)	Benthal Air (SCFM)	Asp. Air (HP)	Sup. Mixer (HP)	Nitrification Air?	Benthal Air (%)
1A	CM	5,530	877	**3,336**	**2,435**	**5,711**	**0**	569	-2	yes	0%
1B	SP	0	0	**0**	**0**	**0**	**1668**	169		no	100%

Equipment Selection

Cell	Diffuser Type	Air per Diffuser (SCFM)	No. of Diffusers	No. of Laterals	Lateral Length (ft)	No. of Units	Aspirator - Hp	No. of Units	Mixer - Hp	Air Flow (SCFM)
1A	HR	18	325	10	510	0	0.0	0	0.0	**5850**
1B	LR	9	192	8	510	0	0.0	0	0.0	**1728**
										0
										0
Total			**517**	**18**		**0**		**0**		**7578**

Stabilization

Estimated Stabilization Area	192,387	sf	Sludge Density	5%	
Biodegradable Solids	1,702	lbs/d	Rate of Sludge Accumulation	1.51	MG/year
Nondegradable Solids	1722	lbs/d	Desludging Volume	6	MG
Stabilzation Loading Rate	43	g-solids/m^2/d	Desludging Interval	4.2	years

LPR Sizing	Winter		**LPR Aeration**	Winter	
Temperature	8.9	deg. C	Cube Total	**176**	Cubes
Influent $CBOD_5$	12	mg/L	Media Depth	8	ft
Effluent $CBOD_5$	12	mg/L	BOD Oxygen Requirement	0	lbs/day
BOD Load	0	lbs/d	NH_3 Oxygen Requirement	2,803	lbs/day
BOD Cube Density	48	sf/cf	Total Oxygen Requirement	2,803	lbs/day
Loading Rate	0.00169	lb-$CBOD_5$/sf/d	Transfer Efficiency	13.3%	
BOD Cubes Required	**0**	Cubes	LPR Aeration	1,700	SCFM
Influent Ammonia	46	mg/L	LPR Mixing	1760	SCFM
Effluent Ammonia	2	mg/L			
Ammonia Load	609	lbs/day	Channels	16	Channels
NH3 Cube Density	69	sf/cf	Spaces per Channel	11	Cubes
Loading Rate	0.00018	lb-NH_3/sf/d	Unused Spaces	0	Spaces
NH3 Cubes Required	**172**	Cubes	Detention Time	**10.6**	Hours

Blower Sizing

Maximum Water Depth	**10**	Feet	Blower Efficiency	**66.8**	%
Aeration Req.	**9,338**	SCFM	Blower Motor Power Req.	**443.4**	BHP
Mass Air Flow	**11.7**	lb/s	Number of Blowers	**4**	Units
Outlet Blower Pressure	**5.63**	psig	**Suggested Blower Size**	**200**	HP

Transfer Rates for Mechanical Aeration

SOTR	2.0	lb-O_2/HP/hr
OTR, summer	0.70	lb-O_2/HP/hr
OTR, winter	0.79	

Equipment Summary

Insulated Cover

Cover	**314,600**	square feet
R-Value	**8**	R
Walkway Casings Adder	**71,280**	square feet

Hydraulic Baffle

Total Baffle Length	**554**	ft
Baffle Depth	**11**	ft
Number of Baffles	**1**	

Mooring Equipment

Cable	**0**	feet
Posts	**0**	units

Aeration	Aeration	LPR	
Total Length	**9180**	**1408**	feet
Laterals	**18**	**16**	
Diameter	**4**	**4**	inches
LR Diffusers	**192**	**0**	units
HR Diffusers	**325**	**0**	units
2HR Diffusers	**0**	**0**	units

LPR		
BOD Cube	**0**	Cubes
Ammonia Cube	**176**	Cubes
Cube Depth	**8**	feet
Lateral Connections	**176**	number

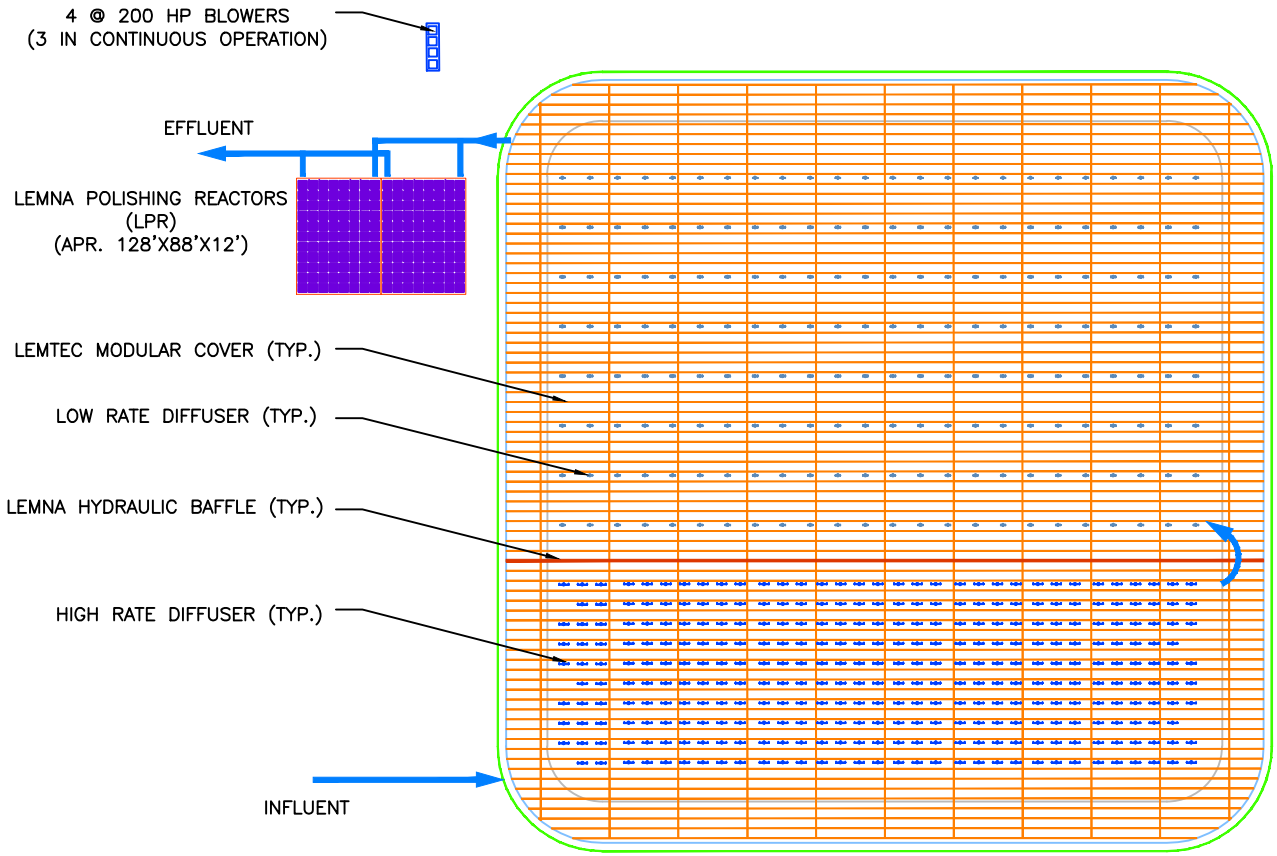
Blower Packages

Blower	**4**	Packages
Motor	**200**	HP
Enclosure	**No**	(Yes/No)

Aspirators and Mixers	Number	HP
Aspirator Size #1	**0**	**0**
Aspirator Size #2	**0**	**0**
Mixer Size #1	**0**	**0**
Mixer Size #2	**0**	**0**

Panels

Number of Panels	**1**	Panels



LEMTEC™ AERATION POND
6.99 ACRE
10' WATER DEPTH
11.7 DAYS D.T.

SETTLING CELL
7.5 DAYS D.T.

COMPLETE MIX CELL
4.2 DAYS D.T.

SITE CHARACTERISTICS:
WINTER AIR TEMPERATURE: −5.0 °C
ELEVATION: 4459 ft AMSL
ATMOSPHERIC PRESSURE: 12.5 psia

INFLUENT CHARACTERISTICS:
$CBOD_5$=408 mg/L
TSS=272 mg/L
NH_3=63 mg/L

EFFLUENT LIMITS:
$CBOD_5$=30 mg/L
TSS=30 mg/L
NH_3=2.0 mg/L

DESIGN FLOW: 1.67 MGD

NOTE: DESIGN BASED ON MINIMUM INFLUENT TEMPERATURE OF 10°C

THIS DESIGN IS PROPIETARY TO LEMNA ENVIRONMENTAL TECHNOLOGIES, INC. AND IS SOLELY INTENDED FOR APPLICATION AT INTERLOCHEN STATE PARK, MI BY LEMNA ENVIRONMENTAL TECHNOLOGIES, INC. THIS DESIGN CANNOT BE USED BY A THIRD PARTY NOR REPRODUCED, IN FULL OR IN PART, WITHOUT THE WRITTEN AUTHORIZATION OF LEMNA TECHNOLOGIES, INC.

DRAWN BY: BELGRADE, MT
APPROVED BY: JAM
SCALE: NOT TO SCALE
DATE: JANUARY 2017
SHEET NO: 1 OF 1

LEMTEC™ BIOLOGICAL TREATMENT PROCESS
BELGRADE, MT

L•E•T
LEMNA ENVIRONMENTAL TECHNOLOGIES, INC.
4215 WHITE BEAR PARKWAY, SUITE 200 • VADNAIS HEIGHTS, MN 55110
PHONE: 612-253-2000 FAX: 612-253-2003 WWW.LEMNATECHNOLOGIES.COM

LemTec™ Biological Treatment Process

Proposal For: Belgrade, MT

Prepared for: Nicole Rediske
TD&H Engineering
Great Falls, MT

Prepared by: Tom Birkeland
Director of Sales
LET

Proposal Number: 1550
Revision Number: 0
January 25, 2017

INTRODUCTION

Thank you for including Lemna in the planning of the Belgrade, MT wastewater treatment facility. Based on the information provided, we have developed a preliminary design and budget estimate for this project. The objective of our proposed system is to provide the best possible biological treatment solution capable of meeting or exceeding your requirements in the most efficient and cost effective way possible.

This proposal has been prepared for Ms. Nicole Rediske, who is currently evaluating treatment alternatives, and is interested in products/technologies that can provide improvements to the existing facility, in order to accommodate projected flows as well as meet BOD, TSS and ammonia limits.

Lemna Environmental Technologies' proposed process design is based upon the following design parameters and site data.

DESIGN PARAMETERS

	Influent Summer	Influent Winter		Effluent Summer	Effluent Winter	
Flow	1.67	1.67	MGD			
$CBOD_5$	408	408	mg/L	30	30	mg/L
TSS	272	272	mg/L	30	30	mg/L
Ammonia	63	63	mg/L	2	2	mg/L

The proposed design described below will achieve the basic requirements and provide a number of advantages to the end user which are unmatched by alternative technologies. The LemTec™ process is capable of achieving year-round effluent limits of 20 mg/l BOD, 20 mg/l TSS and 1.5 mg/l NH3-N at a fraction of the cost of other traditional wastewater treatment systems. With a reduced footprint, a process that is extremely reliable, and simple to operate, the LemTec™ process is the highest performance lagoon-based package in the world and offers numerous advantages over other systems, including lower capital and operating costs, expandability and low maintenance.

DESIGN OVERVIEW

This proposed design utilizes one of the existing lagoons to handle a total design flow of 1.67 MGD. The depth of the lagoon will be 10' for the purposes of this design. Following the treatment lagoon, the LemTec™ Polishing Reactor (LRR) will provide additional ammonia treatment.

For this design, the lagoon will be divided into two cells using Lemna's custom designed LemTec™ Reverse Miter Hydraulic, which will be installed to minimize short-circuiting between each cell. The first cell will be a complete mix cell with a detention time of 4.2 days. The complete mix zone of the LBTP process is an aerated, aggressively mixed cell that establishes an environment suitable for the rapid removal of BOD_5 by heterotrophic bacteria. The reduction of BOD_5 is calculated using state-of-the-art "mechanistic" models that relate to the growth of bacteria and removal of BOD_5 in relation to detention time and wastewater temperature. Similar models are currently used for the design of activated sludge plants.

In addition to BOD_5 removal, ammonia is also removed by heterotrophic bacteria present in the complete mix cell. Ammonia is utilized by the bacteria to support its nitrogen requirement for growth. Also, nitrifier growth will occur in the complete mix cell resulting in additional (and significant) ammonia reduction. Aeration and mixing will be provided by fine bubble diffusers.

Following the complete mix cell, water will flow into a settling cell with a detention time of 7.5 days. Both the cells in the proposed design will be covered by Lemna's LemTec™ Modular Insulated Cover rated at R8. The LemTec™ Cover prevents algae growth by eliminating sunlight below the cover and improves clarification in two ways: 1) it prevents wind action on the water surface thereby establishing a quiescent zone for solids to settle, and 2) the insulation minimizes seasonal and diurnal temperature fluctuations, thereby reducing stirring by thermal currents. The LemTec™ Cover improves TSS removal, provides algae prevention and encourages nitrification by regulating temperatures within the treatment system.

Following the treatment lagoon, the LemTec™ Polishing Reactor will provide additional BOD and ammonia treatment. The LPR consists of submerged, attached-growth media modules used for maintaining an adequate population of bacteria. The LPR enhances the growth of nitrification bacteria to encourage conversion of ammonia to nitrates in an aerobic environment. Aeration is provided by rack-mounted coarse-bubble diffusers located under the media, which evenly distribute the air and shear coarse bubbles into very fine bubbles. The LPR produces BOD and TSS effluent levels less than 10 mg/l and NH_3-N as low as 1 mg/l. Typically housed in a concrete or metal structure near the effluent of the pond, the LPR is the final stage of the lagoon based LemTec Biological Treatment Process. The approximate size of the proposed LPR for this option is 128'x88'x12'.

The oxygen requirements for the LPR will be met (4) 200 HP blowers, of which 3 will be in continuous operation. A schematic of the proposed design is attached for your reference.

DESIGN SUMMARY

	Water Depth (ft)	Freeboard (ft)	Slope	Waterline Length (ft)	Waterline Width (ft)	Volume (MG)	Detention Time (days)
Basin # 1	10	7	4	554	550	19.5	11.7

	Mixing	Detention Time (days)	Winter Temp. (C)
Cell 1A	CM	4.2	9.6
Cell 1B	SC	7.5	8.9

A summary of the equipment supplied is provided in the table below:

EQUIPMENT SUMMARY

	Cover	**Baffle**		**Blower**		**Cubes**	**Diffusers**
	Sq. Ft.	**Qty.**	**Ft.**	**Qty.**	**HP**	**6'x6'x8'**	**Units**
Aeration Pond	304,700	1	554	4	200		
Complete Mix							325
Settling							192
LPR	9,900					176	

DESIGN LAYOUT/DRAWINGS

Layout drawings are included.

LET PROJECT SUPPLY SCOPE

Engineering/Technical Services
- Lemna System Design Recommendations
- Lemna System Equipment Details
- Lemna System Plans and Specifications
- Lemna Design Calculations

Regulatory Technical Support

Equipment Supply
- LemTec™ Insulated Cover
- LemTec™ Aeration System
- LemTec™ LPR

Installation/Start-Up/Training
- Equipment Installation Supervision (Lemna Equip.)
- Process Start-Up/Training (Lemna Process)
- Ongoing Technical Support

LET PROJECT PRICING

Equipment/Services Equipment Freight (estimate)	$ 2,893,054 $ 155,946
Total Proposed Price	**$ 2,995,000**

By others: Civil Design, Electrical Design, Mechanical Design, Other Design Services (if required). Pond De-Sludging, Site Work/Improvements, Concrete Structures, Septic Tanks, Yard Piping (out of basin),Electrical Service to Site, Interconnect Wiring (Equipment to Equipment/ Remote Disconnect/MCCs/Control Panels).

Proposed pricing is based on available information and is valid for 60 days. Prices are in US funds and do not include any applicable taxes. All sales are subject to LET's standard terms and conditions. Proposed price subject to change based on changes in final design and final scope at time of bid or based on size changes at time of final survey. Typical equipment lead time is 6-12 weeks after approval of final submittals. Equipment lead time is subject to change based on size of project, complexity of design, customer requirements and shop-loading at time of order.

LIMITED WARRANTY

All LET supplied components are warranted against manufacturer's defects for a period of twelve months. This warranty does not cover wear or damage caused by improper installation, operation or maintenance. In the event of a manufacturer's defect, Lemna will repair or replace the damaged component. A process warranty based on the design parameters included as part of this proposal. This process warranty is contingent upon the full supply by LET of all equipment detailed in this proposal.

Belgrade Wastewater Master Plan
Preliminary Air Header Sizing

A= Cross sectional area (SF)
Q= flow rate (SCFM)
Pa= Prevailing absolute pressure. Sea level is 14.7
Pd= compressor gauge pressure minus the prevailing absolute
V= Design pipe velocity (ft/sec)
* Velocity not to exceed 30 ft/sec

Pipe Diameter=SQRT(A*4/3.14)

A=(144*Q*Pa)/(V*60*(Pd+Pa))

Treatment Lagoons

LEMNA Proposal

Q=	7578	scfm
Pa=	12.5	psi
Pd=	5.63	psi
V=	30	ft/sec

A= 330.9018 square inches

Pipe Diameter= 20.53122

Triplepoint Proposal

Q=	6093	scfm
Pa=	12.5	psi
Pd=	6.18	psi
V=	30	ft/sec

A= 258.224 square inches

Pipe Diameter= 18.13692

Nitrification Reactor

LEMNA Proposal

Q=	1790	scfm
Pa=	12.5	psi
Pd=	5.63	psi
V=	30	ft/sec

A= 78.16235 square inches

Pipe Diameter= 9.97847 inches

Triplepoint Proposal

Q=	2022	scfm
Pa=	12.5	psi
Pd=	8.34	psi
V=	30	ft/sec

A= 76.81142 square inches

Pipe Diameter= 9.891862 inches

PIPE SIZE CALCULATIONS

BELGRADE SEWER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Designed by: NMR
Checked by: CEVJ
Date: 4/12/2017

Wastewater Treatment Plant
Alternative T-4A
Transfer Line D-A

BLUE TEXT = USER INPUTS
RED TEXT = CALCULATION RESULTS
GREEN TEXT = ENERGY EQUATION TERM

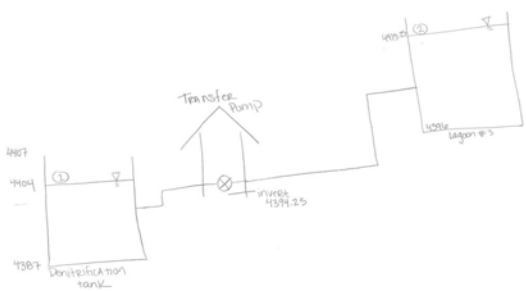
Project Specific Design Criteria:

Q =	**2000**	gpm	(Original pump design capacity)
Q =	**4.4560**	cfs	(1 gal = 0.13368 CF)
v =	**0.0000121**	ft2/sec	(assume water 60°F)

Assumptions:

Only 1 pump is operating.
Use known Q to find the total pump head (total dynamic head TDH).
Darcy-Weisbach friction losses

System Diagram:



Equations:

Energy:

$$\frac{v_1^2}{2g} + z_1 + \frac{P_1}{\gamma} + h_P = \frac{v_2^2}{2g} + z_2 + \frac{P_2}{\gamma} + h_T + h_m + h_f$$

Reynold's Number:

$$Re = \frac{4Q}{\pi D \upsilon}$$

Minor Head Loss:

$$h_m = k\frac{v^2}{2g} = k\frac{Q^2}{2gA^2}$$

Darcy Weisbach Friction Head Loss:

$$h_f = f\frac{Lv^2}{D2g} = f\frac{LQ^2}{D2gA_p^2}$$

Swamee-Jain Friction Factor:

$$f = \frac{0.25}{\left(\log\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{Re^{0.9}}\right)\right)^2}$$

Appropriate if:
10^-6 < ε/D < 10^-2
5000 < Re < 10^8

Hazen-Williams Friction Head Loss:

$$h_f = 3.02LD^{-1.167}\left(\frac{\upsilon}{C_h}\right)^{1.85} = 3.02LD^{-1.167}\left(\frac{Q}{C_h A}\right)^{1.85}$$

PIPE SIZE CALCULATIONS

System Properties:

Tank	Pipe A			Pipe B			Pipe C			Lagoon #3
open to atmosphere	12" PVC			12" SDR18 C900 PVC			10" SDR18 C900 PVC			open to atmosphere
4404	ε =	0.0000625	ft	ε =	0.000416667	ft	ε =	0.0001	ft	4415.25
	ID =	12	in	ID =	12	in	ID =	9.79	in	
	D =	1.000	ft	D =	1.000	ft	D =	0.816	ft	
	A =	0.785	ft2	A =	0.785	ft2	A =	0.523	ft2	
	vp =	5.674	ft/sec	vp =	5.674	ft/sec	vp =	8.524	ft/sec	
	Re =	468,889		Re =	468,889		Re =	574,736		
	ε/D =	0.00006		ε/D =	0.00042		ε/D =	0.000123		
	L =	220	ft	L =	1,256	ft	L =	-	ft	
	f =	0.01412	(S-J eqn)	f =	0.01730	(S-J eqn)	f =	0.01451	(S-J eqn)	
	C_h =	150	(Hazen-Williams)	C_h =	135	(Hazen-Williams)	C_h =	140	(Hazen-Williams)	
	Σk =	15.000	(fittings)	Σk =	15.000	(fittings)	Σk =	-	(fittings)	

Energy Equation:

Each term is calculated separately and then used to find the pump head.

Velocity Head 1
- v1 = 0 ft/sec (negligible)
- g = 32.2 ft/sec2 (gravity)
- 0 ft

Velocity Head 2
- v2 = 0 ft/sec (negligible)
- g = 32.2 ft/sec2 (gravity)
- 0 ft

Elevation Head 1
- z1 = 4404 ft

Elevation Head 2
- z2 = 4415.25 ft

Pressure Head 1
- P1 = 0 LB/ft2 (atmosphere)
- γ = 62.4 LB/ft3
- 0 ft

Pressure Head 2
- P2 = 0 (atmosphere)
- γ = 62.4 LB/ft2
- 0 ft

Pump Head
- hp = 38.66 ft RESULT

Turbine Head
- hT = 0 ft (N/A)

Friction Head Loss

Darcy-Weisbach (Used in Energy Equation):
- g = 32.2 ft/sec2 (gravity)
- Pipe A: hf = 1.55 ft
- Pipe B: hf = 10.86 ft
- Pipe C: hf = 0.00 ft

Hazen-Williams (Check only):
- Pipe A: hf = 1.553 ft
- Pipe B: hf = 10.777 ft
- Pipe C: hf = - ft

Minor Head Loss
- g = 32.2 ft/sec2 (gravity)
- Pipe A: hm = 7.50 ft
- Pipe B: hm = 7.50 ft
- Pipe C: hm = 0.00 ft

PIPE SIZE CALCULATIONS

BELGRADE SEWER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Designed by: NMR
Checked by: CEVJ
Date: 4/12/2017

Wastewater Treatment Plant
Alternative T-4A
Transfer Line B-A Sizing

BLUE TEXT = USER INPUTS
RED TEXT = CALCULATION RESULTS
GREEN TEXT = ENERGY EQUATION TERM

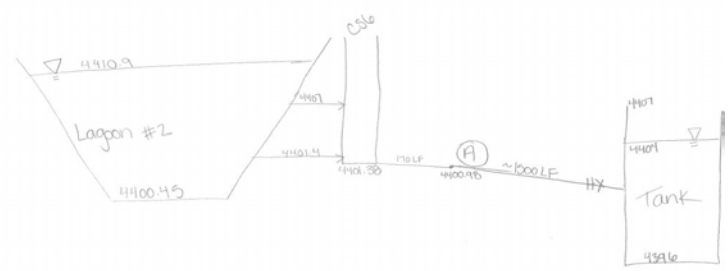
Project Specific Design Criteria:

Q =	**1843.822131** gpm	(Original pump design capacity)	2,655,104 gpd
Q =	**4.1080** cfs	(1 gal = 0.13368 CF)	
v =	**0.0000121** ft2/sec	(assume water 60°F)	

Assumptions:

Only 1 pump is operating.
Use known Q to find the total pump head (total dynamic head TDH).
Darcy-Weisbach friction losses

System Diagram:



Equations:

Energy:

$$\frac{v_1^2}{2g} + z_1 + \frac{P_1}{\gamma} + h_P = \frac{v_2^2}{2g} + z_2 + \frac{P_2}{\gamma} + h_T + h_m + h_f$$

Reynold's Number:

$$Re = \frac{4Q}{\pi D v}$$

Minor Head Loss:

$$h_m = k\frac{v^2}{2g} = k\frac{Q^2}{2gA^2}$$

Darcy Weisbach Friction Head Loss:

$$h_f = f\frac{Lv^2}{D2g} = f\frac{LQ^2}{D2gA_p^2}$$

Swamee-Jain Friction Factor:

$$f = \frac{0.25}{\left(\log\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{Re^{0.9}}\right)\right)^2}$$

Appropriate if:
10^-6 < ε/D < 10^-2
5000 < Re < 10^8

Hazen-Williams Friction Head Loss:

$$h_f = 3.02LD^{-1.167}\left(\frac{v}{C_h}\right)^{1.85} = 3.02LD^{-1.167}\left(\frac{Q}{C_h A}\right)^{1.85}$$

PIPE SIZE CALCULATIONS

System Properties:

Lagoon #2	Pipe A			Pipe B			Pipe C			Tank
open to atmosphere	16" PVC			12" SDR18 C900 PVC			10" SDR18 C900 PVC			open to atmosphere
4410.9	ε =	0.000416667	ft	ε =	0.000416667	ft	ε =	0.0001	ft	4404
	ID =	16	in	ID =	11.65	in	ID =	9.79	in	
	D =	1.333	ft	D =	0.971	ft	D =	0.816	ft	
	A =	1.396	ft2	A =	0.740	ft2	A =	0.523	ft2	
	vp =	2.942	ft/sec	vp =	5.550	ft/sec	vp =	7.859	ft/sec	
	Re =	324,205		Re =	445,261		Re =	529,856		
	ε/D =	0.00031		ε/D =	0.00043		ε/D =	0.000123		
	L =	1,670	ft	L =	-	ft	L =	-	ft	
	f =	0.01703	(S-J eqn)	f =	0.01743	(S-J eqn)	f =	0.01463	(S-J eqn)	
	C_h =	135	(Hazen-Williams)	C_h =	135	(Hazen-Williams)	C_h =	140	(Hazen-Williams)	
	Σk =	30.000	(fittings)	Σk =	-	(fittings)	Σk =	-	(fittings)	

Energy Equation:

Each term is calculated separately and then used to find the pump head.

Velocity Head 1
v1 = 0 ft/sec (negligible)
g = 32.2 ft/sec2 (gravity)
0 ft

Velocity Head 2
v2 = 0 ft/sec (negligible)
g = 32.2 ft/sec2 (gravity)
0 ft

Elevation Head 1
z1 = 4410.9 ft

Elevation Head 2
z2 = 4404 ft

Pressure Head 1
P1 = 0 LB/ft2 (atmosphere)
γ = 62.4 LB/ft3
0 ft

Pressure Head 2
P2 = 0 (atmosphere)
γ = 62.4 LB/ft2
0 ft

Pump Head
hp = (0.00) ft RESULT

Turbine Head
hT = 0 ft (N/A)

Friction Head Loss

Darcy-Weisbach (Used in Energy Equation):
g = 32.2 ft/sec2 (gravity)
Pipe A
hf = 2.87 ft
Pipe B
hf = 0.00 ft
Pipe C
hf = 0.00 ft

Hazen-Williams (Check only):
Pipe A
hf = 3.040 ft
Pipe B
hf = - ft
Pipe C
hf = - ft

Minor Head Loss
g = 32.2 ft/sec2 (gravity)
Pipe A
hm = 4.03 ft
Pipe B
hm = 0.00 ft
Pipe C
hm = 0.00 ft

PIPE SIZE CALCULATIONS

BELGRADE SEWER MASTER PLAN
CITY OF BELGRADE
TD&H Job No. B16-048

Designed by: NMR
Checked by:
Date: 5/22/2017

Wastewater Treatment Plant
Alternative T-4B
Transfer Line B-B (Lagoon #3 WSE=4407ft) Sizing

BLUE TEXT = USER INPUTS
RED TEXT = CALCULATION RESULTS
GREEN TEXT = ENERGY EQUATION TERM

Project Specific Design Criteria:

Q =	**2464.297813** gpm	(Original pump design capacity)	3,548,589 gpd
Q =	**5.4905** cfs	(1 gal = 0.13368 CF)	
v =	**0.0000121** ft2/sec	(assume water 60°F)	

Assumptions:

Only 1 pump is operating.
Use known Q to find the total pump head (total dynamic head TDH).
Darcy-Weisbach friction losses

Equations:

Energy:

$$\frac{v_1^2}{2g} + z_1 + \frac{P_1}{\gamma} + h_p = \frac{v_2^2}{2g} + z_2 + \frac{P_2}{\gamma} + h_T + h_m + h_f$$

Reynold's Number:

$$Re = \frac{4Q}{\pi D \upsilon}$$

Minor Head Loss:

$$h_m = k\frac{v^2}{2g} = k\frac{Q^2}{2gA^2}$$

Darcy Weisbach Friction Head Loss:

$$h_f = f\frac{Lv^2}{D2g} = f\frac{LQ^2}{D2gA_p^2}$$

Swamee-Jain Friction Factor:

$$f = \frac{0.25}{\left(\log\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{Re^{0.9}}\right)\right)^2}$$

Appropriate if:
10^-6 < ε/D < 10^-2
5000 < Re < 10^8

Hazen-Williams Friction Head Loss:

$$h_f = 3.02LD^{-1.167}\left(\frac{\upsilon}{C_h}\right)^{1.85} = 3.02LD^{-1.167}\left(\frac{Q}{C_h A}\right)^{1.85}$$

PIPE SIZE CALCULATIONS

System Properties:

Lagoon #2	Pipe A			Pipe B			Pipe C			Lagoon #3
open to atmosphere	16" PVC			12" SDR18 C900 PVC			10" SDR18 C900 PVC			open to atmosphere
4410.9	ε =	0.000416667	ft	ε =	0.000416667	ft	ε =	0.0001	ft	4407
	ID =	16	in	ID =	11.65	in	ID =	9.79	in	
	D =	1.333	ft	D =	0.971	ft	D =	0.816	ft	
	A =	1.396	ft2	A =	0.740	ft2	A =	0.523	ft2	
	vp =	3.932	ft/sec	vp =	7.417	ft/sec	vp =	10.503	ft/sec	
	Re =	433,306		Re =	595,098		Re =	708,160		
	ε/D =	0.00031		ε/D =	0.00043		ε/D =	0.000123		
	L =	500	ft	L =	-	ft	L =	-	ft	
	f =	0.01664	(S-J eqn)	f =	0.01716	(S-J eqn)	f =	0.01423	(S-J eqn)	
	C_h =	135	(Hazen-Williams)	C_h =	135	(Hazen-Williams)	C_h =	140	(Hazen-Williams)	
	Σk =	10.000	(fittings)	Σk =	-	(fittings)	Σk =	-	(fittings)	

Energy Equation:

Each term is calculated separately and then used to find the pump head.

Velocity Head 1

v1 =	0	ft/sec	(negligible)
g =	32.2	ft/sec2	(gravity)
	0	ft	

Velocity Head 2

v2 =	0	ft/sec	(negligible)
g =	32.2	ft/sec2	(gravity)
	0	ft	

Elevation Head 1

z1 = 4410.9 ft

Elevation Head 2

z2 = 4407 ft

Pressure Head 1

P1 =	0	LB/ft2	(atmosphere)
γ =	62.4	LB/ft3	
	0	ft	

Pressure Head 2

P2 =	0		(atmosphere)
γ =	62.4	LB/ft2	
	0	ft	

Pump Head

hp = (0.00) ft RESULT

Turbine Head

hT = 0 ft (N/A)

Friction Head Loss

Darcy-Weisbach (Used in Energy Equation):

g = 32.2 ft/sec2 (gravity)

Pipe A	hf =	1.50 ft
Pipe B	hf =	0.00 ft
Pipe C	hf =	0.00 ft

Hazen-Williams (Check only):

Pipe A	hf =	1.556 ft
Pipe B	hf =	- ft
Pipe C	hf =	- ft

Minor Head Loss

g = 32.2 ft/sec2 (gravity)

Pipe A	hm =	2.40 ft
Pipe B	hm =	0.00 ft
Pipe C	hm =	0.00 ft

Nicole Rediske - RE: FW: Belgrade Wastewater Lagoons sludge removal (B16-048)

From: Eric Lillberg <ericl@crisafulli.com>
To: Nicole Rediske <Nicole.Rediske@tdhengineering.com>
Date: 5/2/2017 2:33 PM
Subject: RE: FW: Belgrade Wastewater Lagoons sludge removal (B16-048)

Nicole,
You could probably pump it out in a months' time. Now that depends on how difficult it will be to maneuver around the pond. Also how long the dewatering process takes. What is the plan for the dewatering?
Eric

From: Nicole Rediske [Nicole.Rediske@tdhengineering.com]
Sent: Monday, May 1, 2017 3:02 PM
To: Eric Lillberg <ericl@crisafulli.com>
Subject: Re: FW: Belgrade Wastewater Lagoons sludge removal (B16-048)

Hello again Eric,

I misspoke in my previous e-mail. We believe there is about 5.6 MG of sludge in the two treatment cells combined, not in the first cell alone.

Sorry for the confusion,

Nicole Rediske | Engineer
TD&H Engineering
1800 River Drive N. | Great Falls, MT 59401
t:406.761.3010
www.tdhengineering.com

>>> Eric Lillberg <ericl@crisafulli.com> 4/21/2017 11:39 AM >>>
Nicole,
I am pretty sure I found the lagoons on Google Earth, one is over 1000' long. We don't like to run the traverse cable much over 500', so you could go between the aerators. I don't know if that is possible without hitting power cords etc. I think the lagoons are too large to use a slurry pump and just pump them out. Do you have an idea on the volume that needs to be removed? I have attached some information on our unmanned dredges and a rental chart.

ERIC LILLBERG Applications Engineer

Office: 888.817.7011 **Direct:** 406.377.6161

CRISAFULLI
Sludge Removal Systems

From: Nicole Rediske [mailto:Nicole.Rediske@tdhengineering.com]
Sent: Tuesday, April 18, 2017 9:27 AM
To: SRS Crisafulli
Subject: Belgrade Wastewater Lagoons sludge removal (B16-048)

Good Afternoon,

I am working with the city of Belgrade, MT on a Wastewater Master Plan. I was hoping you could help me with some sludge removal ideas. Their existing plant has three aerated basins lined with a 60 mil HDPE liner. In two of the basins the liner is exposed. A thin layer of rip rap covers the liner in the third. Additionally, static tube aerators, standing 6 feet from the bottom of the ponds are included.

The lagoons are large. The two treatment lagoons each have a water surface area of about 7 acres and an operating depth of 10 feet. The storage lagoon has a water surface area of almost 16 acres and an operating depth of 19.25 feet.

Can you provide some guidance into the best method of sludge removal for two scenarios? 1) Protecting the existing liner and aerators or 2) if the liner and aerators were to be removed and replaced. A preliminary cost estimate for both would also be very much appreciated.

Thank you
Nicole Rediske

Nicole Rediske | Engineer

TD&H Engineering

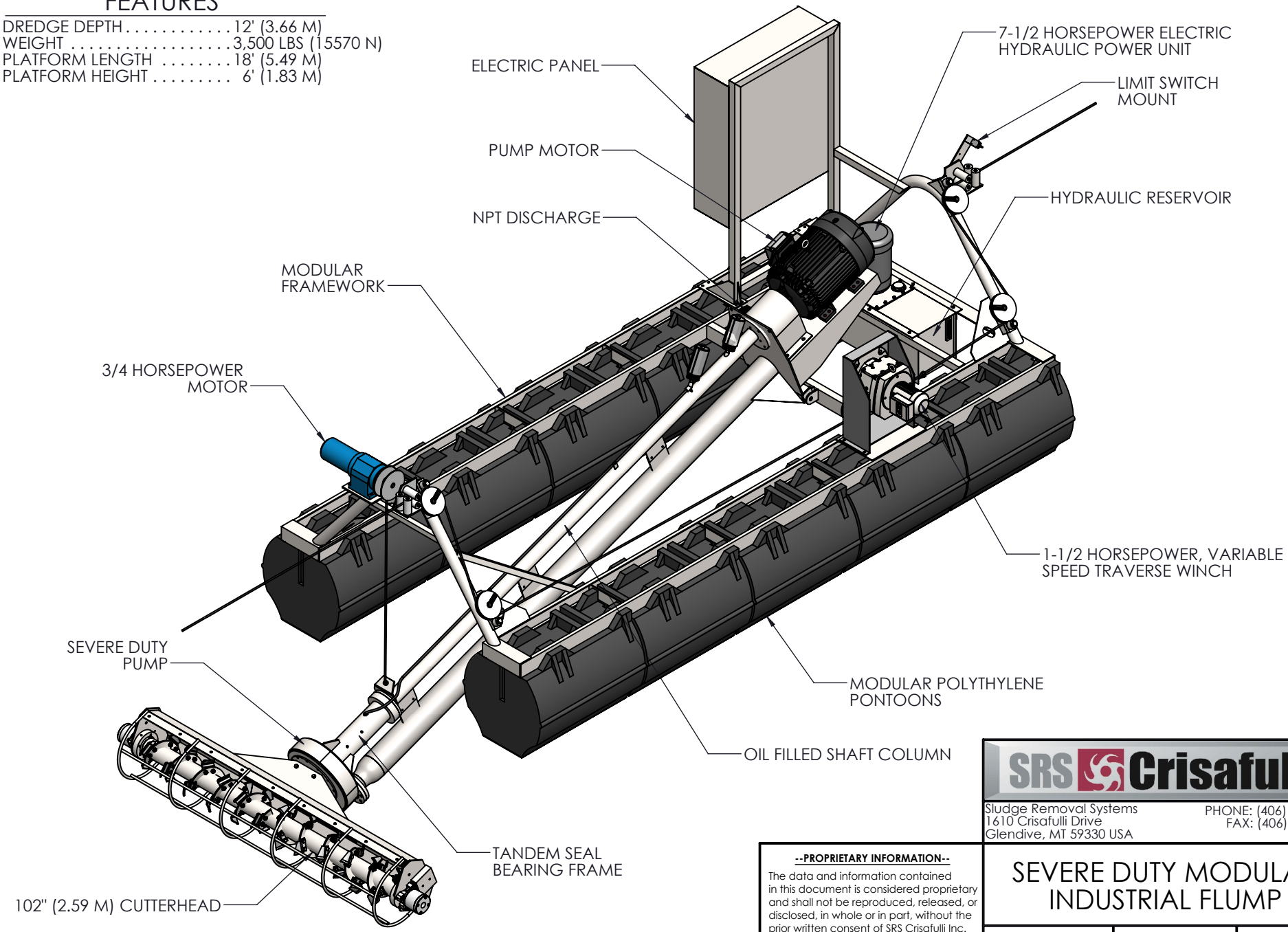
1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

FEATURES

DREDGE DEPTH . . . . . 12' (3.66 M)
WEIGHT . . . . . 3,500 LBS (15570 N)
PLATFORM LENGTH . . . . . 18' (5.49 M)
PLATFORM HEIGHT . . . . . 6' (1.83 M)



SRS Crisafulli
Sludge Removal Systems
1610 Crisafulli Drive
Glendive, MT 59330 USA
PHONE: (406) 365-3393
FAX: (406) 365-8088

--PROPRIETARY INFORMATION--

The data and information contained in this document is considered proprietary and shall not be reproduced, released, or disclosed, in whole or in part, without the prior written consent of SRS Crisafulli Inc. of Glendive, Montana.

SEVERE DUTY MODULAR INDUSTRIAL FLUMP

Drafted By: SDP	Date: 7/22/13	DWG# 96108

CRISAFULLI
Sludge Removal Systems

RENTAL RATES

Effective Jan. 1, 2017

DREDGE MODEL & Description of rental PACKAGE	Rental rate
ROTOMITE 6000CD package including: ❖ Rotomite 6000CD Dredge; ❖ 305' of 8" diameter floating discharge line; ❖ (Optional) Traverse system to cover a 300' x 600' area.	$38,500 initial month $34,500 monthly thereafter $24,250 Damage deposit* plus round-trip freight
ROTOMITE 6000 package including: ❖ Rotomite 6000 Dredge; ❖ 305' of 8" diameter floating discharge line; ❖ (Optional) Traverse system to cover a 300' x 600' area.	$29,885 initial month $25,885 monthly thereafter $15,000 Damage deposit* plus round-trip freight
ROTOMITE SD110 package including: ❖ Rotomite SD110 Dredge; ❖ 305' of 6" diameter floating discharge line; ❖ (Optional) Traverse system to cover a 300' x 600' area.	$22,650 initial month $18,650 monthly thereafter $11,000 damage deposit* plus round-trip freight
FLUMP 4" SEVERE DUTY package including: ❖ 4" severe duty 50 HP FLUMP dredge; ❖ Handheld radio remote control; 500' of power & control cord; ❖ 305' of 6" diameter floating discharge line; ❖ Traverse system, 4-post manual, to cover a 300' x 600' area.	$16,700 initial month $12,700 monthly thereafter $8,250 damage deposit* plus round-trip freight
FLUMP, 3" STANDARD DUTY package including: ❖ 3" standard duty 25 HP FLUMP dredge; ❖ Handheld radio remote control; 500' of power & control cord; ❖ 305' of 6" diameter floating discharge line; ❖ Traverse system, 4-post manual, to cover a 300' x 600' area.	$14,800 initial month $10,800 monthly thereafter $7,400 Damage deposit* plus round-trip freight
ADDITIONAL FLOATING DISCHARGE LINE	MONTHLY RENTAL RATE
6" diameter x 15' length, rigid section, including couplings	$92.00 each/month
6" diameter x 5' length, flexible section, including couplings	$40.00 each/month
8" diameter x 15' length, rigid section, including couplings	$110.00 each/month
8" diameter x 20' length, flexible section, including couplings (Poly/Foam)	$140.00 each/month
8" diameter x 5' length, flexible section, including couplings	$55.00 each/month

*Damage deposit may be credited and/or refunded upon return of all rental equipment in satisfactory condition.
SRS Crisafulli reserves the right to revise above rental rates and damage deposits based on intended application.
Rates are subject to change without notice. Rentals are available within the United States and (on a limited basis) in Canada.

Call to inquire about our "Try Before You Buy" program!
Initial month rental fee *credited toward dredge purchase*

Please call our Factory for any special request Rental items. Toll-free: 1-800-442-7867

SRS Crisafulli Inc. ▯ 1610 Crisafulli Drive ▯ Glendive MT 59330 ▯ USA ▯ Ph: 406-365-3393 ▯ Toll-free 800-442-7867 Fax: 406-365-8088

Email: srsc@crisafulli.com ▯ Website: www.crisafullipumps.com

DEQ CORRESPONDENCE

Nicole Rediske - RE: FW: Belgrade Wastewater Master Plan (TDH B16-048)

From: "Campbell, Terry" <tcampbell@mt.gov>
To: Nicole Rediske <Nicole.Rediske@tdhengineering.com>
Date: 4/7/2017 10:59 AM
Subject: RE: FW: Belgrade Wastewater Master Plan (TDH B16-048)

Hi Nicole:

These complete mix aerated lagoon designs are something outside-the-box with respect to DEQ 2 or the Ten States Standards. The design standards (Ten State) primarily were constructed to achieve secondary limits only. DEQ 2 has added components for newer nutrient removal facilities, but we haven't kept up with the industry – nor have other states. With respect to complete mix designs, we have really only had a couple of facility designs including the Three Forks project design submitted for DEQ review to date – so not a lot of experience with them. Alberton did something similar with Lemna baffles and floating cover, but not really a complete mix design and no ammonia or TN limit there. The Montana Law Enforcement Academy here in the Helena valley did a complete mix design that wasn't a Lemna package, but they are strictly a land application discharger, so that also is different. The Three Forks design met all of the Table 93.2 criteria for a continuous discharge facility.

I do think that because Belgrade uses IP "controlled discharge" in conjunction with spray irrigation, the minimum number of aerated cells per DEQ 2 would need to be 3 – but having the large storage cell could, in this my mind, negate that need (serve as a third cell) and be sufficient to replace the third aerated cell if only secondary standards were contained and expected in the discharge permit. Also, the storage cell could be used in the overall detention time calculation – even though it is facultative.

Unfortunately when we review projects like this at DEQ, you don't always get a consistent take on what standards apply. So one reviewer might take a strict look at that 20 day detention time in the table and tell you to apply for a deviation. I would view this design as something that doesn't fit that partial mix standard and would try to review without using the deviation process and just have the designer do an adequate job of justifying a treatment outcome.

Having said that – I would view 12.5 days of detention time within the "treatment" cells as pretty minimal for a facility that has an ammonia or TN limit and doesn't recycle flow like an activated sludge process. I don't think you could expect much further TN reduction in the storage cell prior to discharge (so that would put a lot of reliance on the carbon filter option) – you might get good BOD reduction in the storage cell and TSS could go either way, depending on algae. If the discharge permit contained only secondary standards for BOD and TSS, I would be less concerned and likely to approve. I think until we have more experience and comfort with the performance of these complete mix designs, we would need very strong supporting data to approve a reduction from the 20 day detention time criteria for the "treatment cells" at facilities that have ammonia or TN limits.

For land application projects, it is better to not convert ammonia to nitrite/nitrate. Plants are better able to quickly utilize the ammonia form of nitrogen. Also, the land area under irrigation was likely

sized for a TN load, so if you significantly reduce the TN being discharged to the land area, they may be able to use more water on the crop. This may not be key to the Belgrade design, but I just wanted to mention these issues.

Anyway, without more detail of the alternative you are looking at those are my initial thoughts and hope they are helpful in guiding your analysis. Feel free to contact me at any time and I will do my best to discuss with others here and provide feedback.

Terry Campbell, PE
DEQ WPCSRF Program
(406) 444-7343

From: Nicole Rediske [Nicole.Rediske@tdhengineering.com]
Sent: Thursday, April 06, 2017 3:32 PM
To: Campbell, Terry
Subject: RE: FW: Belgrade Wastewater Master Plan (TDH B16-048)

Good Afternoon Terry,

I have been looking more closely at some of design information from LEMNA regarding the possible Belgrade lagoon upgrades. The conceptual design that has been provided to me has a complete mix cell with high rate diffusers, a settling cell with low rate diffusers, and the LEMNA Polishing reactor. Based on the 20-year design average day flow rate, the detention time for the complete mix cell is 4.2 days, for the settling cell it is 7.5 day and the LPR is 0.6 days, for a total detention time under aeration of 12.3 days. DEQ-2 lists the required detention time for partially aerated lagoons with land application at 15 days. LEMNA has calculated effluent concentrations of 30 mg/l BOD and TSS and 2.0 mg/l ammonia.

Belgrade's discharge permit set limits on total nitrogen so LEMNA has suggested sending the effluent through a series of 6 carbon filters to get TN concentrations below 13.5 mg/l.

The City's existing storage lagoon has an operating capacity of 81.5 MG, and would remain to store treated water for disposal by irrigation and IP beds.

My question for you is do you have a feel for how likely it would be for us to get a deviation approved for a slightly shorter detention time?

Thank you,

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

DEQ CORRESPONDENCE

>>> "Campbell, Terry" <tcampbell@mt.gov> 3/8/2017 9:07 AM >>>
No worries. Our email has been acting up a bit of recent, so possible it just didn't get out of the state system

Terry

From: Nicole Rediske [mailto:Nicole.Rediske@tdhengineering.com]
Sent: Wednesday, March 08, 2017 9:03 AM
To: Campbell, Terry
Subject: Re: FW: Belgrade Wastewater Master Plan (TDH B16-048)

thank you! sorry for the confusion.
>>> "Campbell, Terry" <tcampbell@mt.gov> 3/8/2017 8:54 AM >>>
Here is what I sent yesterday.

Terry

From: Campbell, Terry
Sent: Tuesday, March 07, 2017 2:15 PM
To: Lavigne, Paul; Nicole Rediske
Cc: Camille Johnson; Dustin Nett; Keith Waring; Matt McGee; Wade DeBoo
Subject: RE: Belgrade Wastewater Master Plan (TDH B16-048)

Nicole (all):

The Three Forks project was reviewed in 2011 & 2012 under the aerated lagoon standards as a partial mix aerated lagoon facility. In reality, the primary cell is a complete mix cell, where the following cells are stepped aeration/settling basins. They also included a Lemna polishing reactor and UV disinfection. The polishing reactor is an post lagoon mechanical addition that uses fixed film and intensive aeration in a channelized concrete basin to nitrify remaining ammonia prior to discharge. That component really didn't fit any portion of the DEQ 2 standard, so from our review perspective was considered "experimental". We had pretty good supporting documentation from the Lemna folks up front on performance capabilities of that polishing reactor.

The only deviations secured for the project were with respect to liner testing (only primary cell was hydraulically tested and others constructed in same manner with electrostatic tests) and a second deviation having to do with the influent channel construction details. All other portions of the design met the standards applied under review.

Three Forks has an ammonia limit in the discharge permit due to the receiving water being cold water salmonid stream, but there were no impairments for nutrients or metals on the receiving stream at the time the project was reviewed.

DEQ CORRESPONDENCE

We will know in a few months how the system performs. Substantial completion of this project was just achieved last month. The AOC for the system gives them several months to develop the biology before they must meet permit conditions.

Terry Campbell, PE
DEQ WPCSRF Program
(406) 444-7343

From: Lavigne, Paul
Sent: Tuesday, March 07, 2017 1:17 PM
To: Nicole Rediske
Cc: Camille Johnson; Dustin Nett; Keith Waring; Matt McGee; Wade DeBoo; Campbell, Terry
Subject: RE: Belgrade Wastewater Master Plan (TDH B16-048)

Nicole, I know that Glasgow put in a Lemna system a few years ago and Three Forks is wrapping their Lemna system up this spring, so it's doable- not sure which deviations were processed though. Terry Campbell (copied here) may be able to provide more information on this project.

Attached is the lagoon optimization report for Belgrade, conducted by our contractor, Steve Harris. This work included a fairly rigorous sludge depth measurement procedure among other things.
I hope this helps.
Thanks.
Paul

From: Nicole Rediske [mailto:Nicole.Rediske@tdhengineering.com]
Sent: Tuesday, March 07, 2017 10:02 AM
To: Lavigne, Paul
Cc: Camille Johnson; Dustin Nett; Keith Waring; Matt McGee; Wade DeBoo
Subject: Belgrade Wastewater Master Plan (TDH B16-048)

Good Afternoon Paul,

TD&H Engineering is working with the City of Belgrade on a Wastewater Master Plan. We are currently is the process of evaluating the existing treatment lagoons and assessing possible upgrades. We have been in contact with various advanced aeration systems suppliers such as LEMNA and TriplePoint for possible upgrades. We were unsure if these types of modified aerated lagoon systems are reviewed under the biological lagoon or mechanical system standards. Either way, it looks as if a number of deviations from DEQ-2 will be required in order to get DEQ approval.

Are you aware of any such advanced aeration systems that have been recently constructed in Montana? If so, can you provide any insight into the best approach for obtaining DEQ approval and the likelihood of deviations being accepted?

Also, do you know who to contact for a copy of the sludge survey that was conducted by DEQ last year. The operator recently mentioned that some from DEQ was on-site last year to measure sludge depths in the lagoons.

Please feel free to contact me with any comments or concerns at 406-761-3010.

Thank you,

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

DEQ CORRESPONDENCE

DEQ CORRESPONDENCE

Nicole Rediske - RE: Belgrade Wastewater Master Plan (TDH B16-048)

From: "Lavigne, Paul" <plavigne@mt.gov>
To: Nicole Rediske <Nicole.Rediske@tdhengineering.com>
Date: 3/7/2017 1:18 PM
Subject: RE: Belgrade Wastewater Master Plan (TDH B16-048)
Cc: Camille Johnson <Camille.Johnson@tdhengineering.com>, Dustin Nett <Dusti...
Attachments: Belgrade STP Performance Evaluation final.pdf

Nicole, I know that Glasgow put in a Lemna system a few years ago and Three Forks is wrapping their Lemna system up this spring, so it's doable- not sure which deviations were processed though. Terry Campbell (copied here) may be able to provide more information on this project.

Attached is the lagoon optimization report for Belgrade, conducted by our contractor, Steve Harris. This work included a fairly rigorous sludge depth measurement procedure among other things.
I hope this helps.
Thanks.
Paul

From: Nicole Rediske [Nicole.Rediske@tdhengineering.com]
Sent: Tuesday, March 07, 2017 10:02 AM
To: Lavigne, Paul
Cc: Camille Johnson; Dustin Nett; Keith Waring; Matt McGee; Wade DeBoo
Subject: Belgrade Wastewater Master Plan (TDH B16-048)

Good Afternoon Paul,

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Also, do you know who to contact for a copy of the sludge survey that was conducted by DEQ last year. The operator recently mentioned that some from DEQ was on-site last year to measure sludge depths in the lagoons.

Please feel free to contact me with any comments or concerns at 406-761-3010.

Thank you,

DEQ CORRESPONDENCE

Nicole Rediske | Engineer

TD&H Engineering

1800 River Drive N. | Great Falls, MT 59401

t:406.761.3010

www.tdhengineering.com

Belgrade Wastewater Master Plan
Estimated Heat Exchanger Energy Cost

Flow Rate	1,670,000	gpd
	69,583	gph
Density of Water	8.34	lb/gal
Water Mass Flow	580,325	lb/hr
Final Temperature	5	°C
	44	°F
Initial Temperature	2	°C
	35.6	°F
Change in Temperature	3	°C
	8.4	°F
Energy Required	4,874,730	BTU/hr
	49	Therms/hr
	1,429	kW-hr/hr
	116,993,520	BTU/day
	1,170	Therms/day
	34,287	kW-hr/day
HX Efficiency	80%	
HX Energy Required	6,093,413	BTU/hr
	61	Therms/hour
	1,786	kW-hr/hr
	146,241,900	BTU/day
	1,463	Therms/day
	42,859	kW-hr/day
	5,143,112	kW-hr/year
Natural Gas Cost	0.95	$/Therm
Electricity Cost	0.1	$/kW-hr

* Assuming the HX runs 24 hr/day

*Assuming the HX is only required for November to February

Days of Energy Consumption	120	days per year
Estimated Annual Natural Gas Cost	$166,756	
Estimated Annual Electrical Cost	**$514,311**	

Belgrade Wastewater Master Plan
Estimated Transfer Pump Energy Cost

Motor Horse Power=	40	HP
	29828	W
	29.828	kW
Assumed Pump Run Time=	14	hr/day
Daily Energy Requirement=	417.592	kW-hr
Annual Energy Requirement=	152421.1	kw-hr
Electricity Cost=	0.1	$/kW-hr
Total Daily Transfer Pump Cost	$42	
Total Annual Transfer Pump Cost	**$15,242**	

Belgrade Wastewater Master Plan
Estimated Blower Energy Cost
LEMNA Design

Current Average Day Flow =	716,737	gpd
Design Average Day Flow=	1,670,000	gpd
% of Design Flow=	42.92%	

Treatment Lagoon and Nitrification Reactor

Design required blower motor=	443.4	HP
Number of continuous blowers=	3	blowers
Design blower motor=	200	HP/blower
	600	HP
Required/Design HP (%)=	73.90%	

Estimated Blower Run Time at Design Flow=	17.74	hr/day
Estimated Blower Run Time at Current Flow=	7.61	hr/day

Estimated Blower Energy Consumption

Electricity Cost	0.1	$/kW-hr

Aeration Lagoons and Nitrification Tank (combined)

	Current Condition	Design Condition	
Blower Run Times	7.61	17.74	hr/day
Power Consumption	447.4	447.4	kW
Daily Power Consumption	3,406	7,935	kW-hr
Daily Cost	$340.58	$793.54	
Annual Cost	$124,310.35	$289,643.60	

Storage Lagoon

Number of Blower	1	blowers
Blower HP	50	hp/blower
Total Required	50	hp
Efficiency	0.85	
Assumed Blower Run Times	24	hr/day
Power Consumption	43.86	kW
Daily Power Consumption	1,052.75	kW-hr

O&M CALCULATIONS

Electricity Cost	0.1	$/kW-hr
Daily Cost	$105.28	
Annual Cost	$38,425.48	

	Current Condition	Design Conditions
Total Daily Blower Energy Cost=	$445.85	$898.82
Total Annual Blower Energy Cost=	**$162,735.83**	**$328,069.08**

* Assumes the storage lagoon blower runs 24 hr/days for 365 days/year always

Existing Plant Power Consumption [2]

	Power (kW)	Energy (KW-hr)	Energy Cost[1]	
2013	2,583	1,378,160	$137,816.00	
2014	2,748	1,371,600	$137,160.00	$135,586.67
2015	2,590	1,317,840	$131,784.00	
2016	1,997	1,051,840	$105,184.00	

(1) assumes $0.10/ KW-hr

(2) Power consumption from NW Energy Records to "Lagoon Road", assumed to include all blower, pumps, light, miscellaneous electrical demands.

Belgrade Wastewater Master Plan
Estimated Blower Energy Cost
Triplepoint Design

Current Average Day Flow =	716,737	gpd
Design Average Day Flow=	1,670,000	gpd
% of Design Flow=	42.92%	

MARS SYSTEM

Design required blower motor=	252	HP
Number of continuous blowers=	3	blowers
Design blower motor=	100	HP/blower
	300	HP
Required/Design HP (%)=	84.00%	

Estimated Blower Run Time at Design Flow=	20.16	hr/day
Estimated Blower Run Time at Current Flow=	8.65	hr/day

Estimated Blower Energy Consumption

Electricity Cost	0.1	$/kW-hr

Aeration Lagoons and Nitrification Tank (combined)

	Current Condition	Design Condition	
Blower Run Times	8.65	20.16	hr/day
Power Consumption	223.7	223.7	kW
Daily Power Consumption	1,936	4,510	kW-hr
Daily Cost	$193.56	$451.00	
Annual Cost	$70,650.00	$164,614.77	

NITROX SYSTEM

Design required blower motor=	94.3	HP
Number of continuous blowers=	3	blowers
Design blower motor=	50	HP/blower
	150	HP
Required/Design HP (%)=	62.87%	

Estimated Blower Run Time at Design Flow=	15.09	hr/day
Estimated Blower Run Time at Current Flow=	6.48	hr/day

Estimated Blower Energy Consumption

O&M CALCULATIONS

Electricity Cost	0.1	$/kW-hr

Aeration Lagoons and Nitrification Tank (combined)

	Current Condition	Design Condition	
Blower Run Times	6.48	15.09	hr/day
Power Consumption	111.9	111.9	kW
Daily Power Consumption	724	1,688	kW-hr
Daily Cost	$72.43	$168.77	
Annual Cost	$26,437.68	$61,599.89	

Storage Lagoon

Number of Blower	1	blowers
Blower HP	50	hp/blower
Total Required	50	hp
Efficiency	0.85	
Assumed Blower Run Times	24	hr/day
Power Consumption	43.86	kW
Daily Power Consumption	1,052.75	kW-hr
Electricity Cost	0.1	$/kW-hr
Daily Cost	$105.28	
Annual Cost	$38,425.48	

	Current Condition	Design Conditions
Total Daily Blower Energy Cost=	$371.27	$39,045.25
Total Annual Blower Energy Cost=	**$135,513.16**	**$264,640.14**

* Assumes the storage lagoon blower runs 24 hr/days for 365 days/year always

Existing Plant Power Consumption

	Power (kW)	Energy (KW-hr)	Energy Cost(1)
2013	2,583	1,378,160	$137,816.00
2014	2,748	1,371,600	$137,160.00
2015	2,590	1,317,840	$131,784.00
2016	1,997	1,051,840	$105,184.00

(1) assumes $0.10/ KW-hr

(2) Power consumption from NW Energy Records to "Lagoon Road", assumed to include all blower, pumps, light, miscellaneous electrical demands.

Belgrade Wastewater Master Plan
Estimated Carbon Source Cost

Required Carbon Dosage	365	gpd

Estimated Unit Cost

MicroC	$2.10	per gallon
Methonal	$1.30	per gallon

Annual Carbon Usage	133,225	gallons

Estimated Annual Cost

MicroC	**$279,773**
Methanol	**$173,193**

O&M CALCULATIONS

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF NET POSITION
PROPRIETARY FUNDS
June 30, 2013

	Business-type Activities Enterprise Funds		
	Water Fund	Sewer Fund	Total
ASSETS			
Current assets			
Cash and cash equivalents	$ 1,051,045	$ (276,066)	$ 774,979
Receivables			
Customers, net	89,307	90,076	179,383
Total current assets	1,140,352	(185,990)	954,362
Other assets			
Bond issuance costs, net	8,583	40,456	49,039
Restricted cash and equivalents	343,601	613,005	956,606
Total other assets	352,184	653,461	1,005,645
Property, plant and equipment			
Nondepreciable:			
Land	600	-	600
Construction work in process	755,079	33,511	788,590
Depreciable:			
Buildings and structures	112,292	16,635	128,927
Improvements	2,560,506	12,252,077	14,812,583
Machinery and equipment	387,397	485,691	873,088
Water and tower lines	9,865,464	-	9,865,464
Accumulated depreciation and amortization	(4,379,265)	(4,323,467)	(8,702,732)
Net property, plant and equipment	9,302,073	8,464,447	17,766,520
Total assets	$ 10,794,609	$ 8,931,918	$ 19,726,527

The accompanying notes are an integral part of the financial statements.

(continued)

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF NET POSITION (CONTINUED)
PROPRIETARY FUNDS
June 30, 2013

	Business-type Activities Enterprise Funds		
	Water Fund	Sewer Fund	Total
LIABILITIES			
Current liabilities			
Accounts payable	$ (896)	$ (111)	$ (1,007)
Accrued employee benefits payable	5,000	5,000	10,000
Bonds, notes, and loans payable	127,000	222,000	349,000
Total current liabilities	131,104	226,889	357,993
Noncurrent liabilities			
Revenue bonds due after one year	3,216,000	2,166,000	5,382,000
Other post-employment health benefits	2,449	2,325	4,774
Compensated absences	14,431	14,431	28,862
Total noncurrent liabilities	3,232,880	2,182,756	5,415,636
Total liabilities	3,363,984	2,409,645	5,773,629
NET POSITION			
Net investment in capital assets	6,094,656	6,076,447	12,171,103
Restricted for debt service	-	613,005	613,005
Restricted for employee leave	-	-	-
Restricted for replacement and depreciation	-	-	-
Unrestricted	1,335,969	(167,179)	1,168,790
Total net position	7,430,625	6,522,273	13,952,898
Total liabilities and net position	$ 10,794,609	$ 8,931,918	$ 19,726,527

The accompanying notes are an integral part of the financial statements.

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA

STATEMENT OF REVENUES, EXPENSES AND CHANGES IN FUND NET POSITION

PROPRIETARY FUNDS

Year Ended June 30, 2013

	Business-type Activities Enterprise Funds		
	Water Fund	Sewer Fund	Totals
OPERATING REVENUES			
Charges for services	$ 1,056,129	$ 974,185	$ 2,030,314
OPERATING EXPENSES			
Salaries and benefits	297,067	284,133	581,200
Supplies	15,325	18,165	33,490
Purchased services	280,523	181,405	461,928
Other expenses	12,308	42,464	54,772
Depreciation and amortization	592,335	522,159	1,114,494
Total operating expenses	1,197,558	1,048,326	2,245,884
Operating income (loss)	(141,429)	(74,141)	(215,570)
NONOPERATING REVENUES (EXPENSES)			
Interest income	12,358	2,587	14,945
Interest expense	(81,004)	(104,187)	(185,191)
Grant income	-	-	-
Total nonoperating revenues (expenses)	(68,646)	(101,600)	(170,246)
Income (loss) before other revenues, expenses, gains, losses, and transfers	(210,075)	(175,741)	(385,816)
CAPITAL CONTRIBUTIONS AND TRANSFERS			
Transfers in	-	-	-
Transfers out	(121,025)	(116,525)	(237,550)
Total capital contributions and transfers	(121,025)	(116,525)	(237,550)
Change in net position	(331,100)	(292,266)	(623,366)
NET POSITION, beginning of year	7,761,725	6,814,539	14,576,264
NET POSITION, end of year	$ 7,430,625	$ 6,522,273	$ 13,952,898

The accompanying notes are an integral part of the financial statements.

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF CASH FLOWS
PROPRIETARY FUNDS
Year Ended June 30, 2013

	Business-type Activities Enterprise Funds		
	Water Fund	Sewer Fund	Total
Increase (Decrease) in Cash and Cash Equivalents			
Cash Flows from Operations			
Receipts from customers	$ 1,079,517	$ 975,601	$ 2,055,118
Payments to suppliers	(375,748)	(239,988)	(615,736)
Payments to employees	(305,092)	(292,158)	(597,250)
Net Cash Provided (Used) by Operating Activities	398,677	443,455	842,132
Cash Flows from Noncapital Financing Activities:			
Transfers in	-	-	-
Transfers out	(121,025)	(116,525)	(237,550)
Net Cash Flows from Noncapital Financing Activities	(121,025)	(116,525)	(237,550)
Cash Flows from Capital and Related Financing Activities			
Additions to property, plant and equipment	(1,507,830)	(100,680)	(1,608,510)
Principal paid on bonds, interfund loans, loans and leases	(123,000)	(214,000)	(337,000)
Interest paid on bonds, interfund loans, loans and leases	(81,004)	(104,187)	(185,191)
Issuance of bonds, interfund loans, loans and leases	1,583,298	4,301	1,587,599
Net Cash Flows Provided (Used) by Capital and Related Financing Activities	(128,536)	(414,566)	(543,102)
Cash Flows from Investing Activities			
Interest on investments	12,358	2,587	14,945
Net Cash Flows Provided (Used) by Investing Activities	12,358	2,587	14,945
Net Increase (Decrease) in Cash and Cash Equivalents	161,474	(85,049)	76,425
Cash and Cash Equivalents at Beginning of Year	1,233,172	421,988	1,655,160
Cash and Cash Equivalents at End of Year	$ 1,394,646	$ 336,939	$ 1,731,585
Classified As:			
Current Assets	$ 1,051,045	$ (276,066)	$ 774,979
Restricted Assets	343,601	613,005	956,606
Totals	$ 1,394,646	$ 336,939	$ 1,731,585

The accompanying notes are an integral part of the financial statements.

(continued)

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF CASH FLOWS (CONTINUED)
PROPRIETARY FUNDS
Year Ended June 30, 2013

	Business-type Activities Enterprise Funds		
	Water Fund	Sewer Fund	Total
Operating Income (loss)	$ (141,429)	(74,141)	$ (215,570)
Adjustments to reconcile operating income (loss) to net cash provided by operating activities			
Depreciation and amortization	592,335	522,159	1,114,494
Change in Assets and Liabilities:			
(Increase) Decrease in:			
Accounts receivable	23,388	1,416	24,804
Increase (Decrease) in:			
Accounts payable	(67,592)	2,046	(65,546)
Accrued employee benefits payable	(8,025)	(8,025)	(16,050)
Total adjustments	540,106	517,596	1,057,702
Net cash provided by operating activities	$ 398,677	443,455	$ 842,132

The accompanying notes are an integral part of the financial statements.

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF NET POSITION
PROPRIETARY FUNDS
June 30, 2014

	Business-type Activities Enterprise Funds		
	Water Fund	**Sewer Fund**	**Total**
ASSETS			
Current assets			
Cash and cash equivalents	$ 977,249	$ 50,519	$ 1,027,768
Receivables			
Customers, net	114,020	118,742	232,762
Total current assets	1,091,269	169,261	1,260,530
Other assets			
Restricted cash and equivalents	571,051	379,188	950,239
Property, plant and equipment			
Nondepreciable:			
Land	600	-	600
Depreciable:			
Buildings and structures	112,292	16,635	128,927
Improvements	2,583,580	12,505,119	15,088,699
Machinery and equipment	387,397	489,733	877,130
Water and tower lines	10,661,342	-	10,661,342
Accumulated depreciation and amortization	(5,020,626)	(4,851,867)	(9,872,493)
Net property, plant and equipment	8,724,585	8,159,620	16,884,205
Total assets	$ 10,386,905	$ 8,708,069	$ 19,094,974

The accompanying notes are an integral part of the financial statements.

(continued)

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF NET POSITION (CONTINUED)
PROPRIETARY FUNDS
June 30, 2014

	Business-type Activities Enterprise Funds		
	Water Fund	**Sewer Fund**	**Total**
LIABILITIES			
Current liabilities			
Legal settlement payable	$ 650,000	$ -	$ 650,000
Accrued employee benefits payable	6,000	6,000	12,000
Bonds, notes, and loans payable	139,000	244,000	383,000
Total current liabilities	795,000	250,000	1,045,000
Noncurrent liabilities			
Revenue bonds due after one year	2,565,000	1,888,000	4,453,000
Other post-employment health benefits	10,019	9,888	19,907
Compensated absences	19,330	19,330	38,660
Total noncurrent liabilities	2,594,349	1,917,218	4,511,567
Total liabilities	3,389,349	2,167,218	5,556,567
NET POSITION			
Net investment in capital assets	6,159,585	6,027,620	12,187,205
Restricted for debt service	226,400	318,988	545,388
Restricted for replacement and depreciation	344,651	60,200	404,851
Unrestricted	266,920	134,043	400,963
Total net position	6,997,556	6,540,851	13,538,407
Total liabilities and net position	$ 10,386,905	$ 8,708,069	$ 19,094,974

The accompanying notes are an integral part of the financial statements.

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF REVENUES, EXPENSES AND CHANGES IN FUND NET POSITION
PROPRIETARY FUNDS
Year Ended June 30, 2014

	Business-type Activities Enterprise Funds		
	Water Fund	**Sewer Fund**	**Totals**
OPERATING REVENUES			
Charges for services	$ 1,154,796	$ 1,279,307	$ 2,434,103
OPERATING EXPENSES			
Salaries and benefits	281,262	281,040	562,302
Supplies	17,975	13,865	31,840
Purchased services	280,482	195,434	475,916
Other expenses	662,960	4,436	667,396
Depreciation and amortization	638,707	528,400	1,167,107
Total operating expenses	1,881,386	1,023,175	2,904,561
Operating income (loss)	(726,590)	256,132	(470,458)
NONOPERATING REVENUES (EXPENSES)			
Interest income	9,870	1,413	11,283
Interest expense	(103,349)	(125,967)	(229,316)
Intergovernmental revenues	500,000	-	500,000
Total nonoperating revenues (expenses)	406,521	(124,554)	281,967
Income (loss) before other revenues, expenses, gains, losses, and transfers	(320,069)	131,578	(188,491)
CAPITAL CONTRIBUTIONS AND TRANSFERS			
Transfers out	(113,000)	(113,000)	(226,000)
Change in net position	(433,069)	18,578	(414,491)
NET POSITION, beginning of year	7,430,625	6,522,273	13,952,898
NET POSITION, end of year	$ 6,997,556	$ 6,540,851	$ 13,538,407

The accompanying notes are an integral part of the financial statements.

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF CASH FLOWS
PROPRIETARY FUNDS
Year Ended June 30, 2014

	Business-type Activities Enterprise Funds		
	Water Fund	**Sewer Fund**	**Total**
Increase (Decrease) in Cash and Cash Equivalents			
Cash Flows from Operations			
Receipts from customers	$ 1,130,083	$ 1,250,641	$ 2,380,724
Payments to suppliers	(310,521)	(213,624)	(524,145)
Payments to employees	(267,793)	(267,578)	(535,371)
Net Cash Provided (Used) by Operating Activities	551,769	769,439	1,321,208
Cash Flows from Noncapital Financing Activities:			
Transfers out	(113,000)	(113,000)	(226,000)
Net Cash Flows Provided (Used) by Noncapital Financing Activities	(113,000)	(113,000)	(226,000)
Cash Flows from Capital and Related Financing Activities			
Additions to property, plant and equipment	(61,219)	(223,573)	(284,792)
Principal paid on bonds, interfund loans, loans and leases	(139,000)	(256,000)	(395,000)
Interest paid on bonds, interfund loans, loans and leases	(103,349)	(125,967)	(229,316)
Amortization of bond issuance costs	8,583	40,456	49,039
Net Cash Flows Provided (Used) by Capital and Related Financing Activities	(294,985)	(565,084)	(860,069)
Cash Flows from Investing Activities			
Interest on investments	9,870	1,413	11,283
Net Cash Flows Provided (Used) by Investing Activities	9,870	1,413	11,283
Net Increase (Decrease) in Cash and Cash Equivalents	153,654	92,768	246,422
Cash and Cash Equivalents at Beginning of Year	1,394,646	336,939	1,731,585
Cash and Cash Equivalents at End of Year	$ 1,548,300	$ 429,707	$ 1,978,007
Classified As:			
Current Assets	$ 977,249	$ 50,519	$ 1,027,768
Restricted Assets	571,051	379,188	950,239
Totals	$ 1,548,300	$ 429,707	$ 1,978,007

The accompanying notes are an integral part of the financial statements.

(continued)

O&M CALCULATIONS

CITY OF BELGRADE, MONTANA
STATEMENT OF CASH FLOWS (CONTINUED)
PROPRIETARY FUNDS
Year Ended June 30, 2014

	Business-type Activities Enterprise Funds		
	Water Fund	**Sewer Fund**	**Total**
Operating Income (loss)	$ (726,590)	256,132	$ (470,458)
Adjustments to reconcile operating income (loss) to net cash provided by operating activities			
Depreciation and amortization	638,707	528,400	1,167,107
Change in Assets and Liabilities:			
(Increase) Decrease in:			
Accounts receivable	(24,713)	(28,666)	(53,379)
Increase (Decrease) in:			
Accounts payable	650,896	111	651,007
Accrued employee benefits	13,469	13,462	26,931
Total adjustments	1,278,359	513,307	1,791,666
Net cash provided by operating activities	$ 551,769	769,439	$ 1,321,208

The accompanying notes are an integral part of the financial statements.

O&M CALCULATIONS

Alternative T-4:

Sequencing Batch Reactor
with
Facultative Biosolids Storage Lagoon

Alternative T-4: Sequencing Batch Reactor w/ Facultative Biosolids Storage Lagoon Engineer's Opinion of Probable Construction Cost				
Construction Costs				
General Conditions				
Bonding / Insurance / Project Mgmt & Admin. / Mobilization			$	715,800.00
Site Work				
Site Management / SWPPP		$ 53,200.00		
Solids Handling & Misc. Demo		$ 740,500.00		
Headworks		$ 12,600.00		
SBR		$ 353,900.00		
Site Improvements - (Grading & Site Piping)		$ 164,925.00		
SUBTOTAL: SITE WORK			$	1,325,100.00
Structural & Architectural				
Headworks		$ 544,000.00		
Control Building Upgrades		$ 101,800.00		
SBR		$ 3,400,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	4,045,800.00
Process Equipment & Piping				
Headworks		$ 633,100.00		
Control Building Upgrades		$ 95,490.00		
SBR		$ 1,834,100.00		
Installation & Start-Up		$ 768,800.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	3,331,500.00
Mechanical				
Headworks		$ 14,300.00		
Control Building Upgrades		$ 9,000.00		
Installation & Start-Up		$ 3,495.00		
SUBTOTAL: MECHANICAL			$	26,800.00
Electrical				
Electrical / Instrumentation & Controls			$	1,496,400.00
SUBTOTAL			$	10,941,400.00
Undeveloped Design Details	10%		*$*	*1,094,200.00*
Construction Contingencies	15%		*$*	*1,641,200.00*
SUBTOTAL: ESTIMATED CONSTRUCTION COST			$	13,676,800.00
NON-CONSTRUCTION COSTS				
SUBTOTAL: Administrative / Engineering / & Legal			**$**	**3,420,000.00**
TOTAL ESTIMATED PROJECT COST			**$**	**17,096,800.00**

Supporting Costs For
Headworks Construction and Equipment Costs

CONSTRUCTION COSTS				
General Conditions				
Bonding / Insurance / Project Mgmt & Admin / Mobilization			$	111,500.00
Site Work				
Site Prep - Clearing and Grubbing		$ 1,600.00		
Excavation & Backfill		$ 11,000.00		
SUBTOTAL: SITE WORK			$	12,600.00
Structural & Architectural				
Geotech & Foundation Systems		$ 58,000.00		
Building Cost		$ 315,000.00		
Channels & Grit Chamber		$ 70,800.00		
Bridge Cranes and Specialties		$ 100,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	544,000.00
Process Equipment & Piping				
Screens		$ 236,900.00		
Washer / Compactor		$ 51,500.00		
Grit Equipment		$ 231,800.00		
Instrumentation		$ 30,900.00		
Influent Flow Sampler		$ 12,400.00		
Process Gates, Piping, Flow Control, etc.		$ 59,300.00		
Process Pumps		$ 10,300.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	633,100.00
Mechanical				
HVAC		$ 9,000.00		
PLUMBING		$ 5,300.00		
SUBTOTAL: MECHANICAL			$	14,300.00
Electrical				
Electrical / Instrumentation & Controls			$	388,500.00
SUBTOTAL			**$**	**1,704,000.00**
Underdeveloped Design Details	10%		$	170,400.00
Construction Contingencies	15%		$	255,600.00
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$**	**2,130,000.00**

Alternative T-4
Supporting Costs for Control Building Renovations

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	-		
Excavation & Backfill	$	-		
SUBTOTAL: SITE WORK			$	-
Structural & Architectural				
Geotech & Foundation Systems	$	-		
Building Cost	$	221,400.00		
Furnishing (Lab / office / control room / shop)	$	187,100.00		
Miscelaneous Metal and Stair Fabrications	$	100,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	101,800.00
SCADA Control Equipment and Misc. Equipment				
SCADA System	$	318,300.00		
STANDBY GENERATOR AND SWITCH GEAR				
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	95,490.00
Mechanical				
HVAC	$	18,900.00		
PLUMBING	$	11,100.00		
SUBTOTAL: MECHANICAL			$	9,000.00
Electrical				
Electrical / Instrumentation & Controls			$	5,400.00
TOTAL ESTIMATED PROJECT COST			**$**	**211,690.00**

Alternative T-4
Supporting Costs for SBR Basins & Facultative Storage Lagoons

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	17,900.00		
Excavation & Backfill	$	336,000.00		
SUBTOTAL: SITE WORK			$	353,900.00
Structural & Architectural				
Geotech & Foundation Systems	$	444,000.00		
Concrete Basins	$	2,751,000.00		
Ladders, Railing, and Misc. Metals.	$	205,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	3,400,000.00
Process Equipment & Piping				
Air Compressors	$	571,300.00		
Air Diffusion Equipment	$	144,200.00		
Submersible Mixers	$	102,500.00		
Decanters	$	156,400.00		
WAS Pumps	$	23,700.00		
Control System	$	97,200.00		
Motor Conrol Center	$	30,500.00		
Instrumentation	$	18,500.00		
Spare Parts	$	4,300.00		
Pumps	$	9,800.00		
Influent Flow Control / Effluent Process Pipng	$	346,700.00		
Chemical Feed	$	91,100.00		
Ancillary Equipment & Systems	$	157,900.00		
Surface Aerator Equipment	$	80,000.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	1,834,100.00
Mechanical				
HVAC	$	-		
PLUMBING	$	-		
SUBTOTAL: MECHANICAL			$	-
Electrical				
Electrical / Instrumentation & Controls			$	958,000.00
TOTAL ESTIMATED CONSTRUCTION COST			**$**	**6,546,000.00**

Alternative T-5A:

Greenfield Sequencing Batch Reactor

Alternative T-5A: Greenfield SBR Facility
Engineer's Opinion of Probable Construction Cost

CONSTRUCTION COSTS				
General Conditions				
Bonding / Insurance / Project Mgmt. & Admin. / Mobilization			$	1,748,600.00
Site Work				
Land Acquisition		$ 500,000.00		
Site Management / SWPPP		$ 62,600.00		
Headworks		$ 12,600.00		
Control Building		$ -		
SBR		$ 353,900.00		
UV Disinfection		$ 11,000.00		
Digestion & Biosolids		$ 53,900.00		
Site Improvements - (Grading & Site Piping)		$ 194,130.00		
SUBTOTAL: SITE WORK			$	1,188,100.00
Structural & Architectural				
Headworks		$ 544,000.00		
Control Building		$ 1,334,000.00		
SBR		$ 3,400,000.00		
UV Disinfection		$ 274,000.00		
Digestion & Biosolids		$ 1,867,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	7,419,000.00
Process Equipment & Piping				
Headworks		$ 633,100.00		
Control Building		$ 1,023,900.00		
SBR		$ 1,723,700.00		
UV Disinfection		$ 314,819.22		
Digestion & Biosolids		$ 5,234,000.00		
Installation & Start-Up		$ 2,678,900.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	11,608,400.00
Mechanical				
Headworks		$ 14,300.00		
Control Building		$ 9,000.00		
SBR		$ -		
UV Disinfection		$ 9,500.00		
Digestion & Biosolids		$ 26,300.00		
Installation & Start-Up		$ 8,865.00		
SUBTOTAL: MECHANICAL			$	68,000.00
Electrical				
Electrical / Instrumentation & Controls			$	4,696,400.00
SUBTOTAL				
Undeveloped Design Details	10%		*$*	*2,672,900.00*
Construction Contingencies	15%		*$*	*4,009,300.00*
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$**	**33,410,700.00**
NON-CONSTRUCTION COSTS				
SUBTOTAL: Administrative / Engineering / & Legal			**$**	**8,353,000.00**
TOTAL ESTIMATED PROJECT COST			$	41,763,700.00

Supporting Costs For
Headworks Construction and Equipment Costs

CONSTRUCTION COSTS				
General Conditions				
Bonding / Insurance / Project Mgmt & Admin / Mobilization			$	111,500.00
Site Work				
Site Prep - Clearing and Grubbing		$ 1,600.00		
Excavation & Backfill		$ 11,000.00		
SUBTOTAL: SITE WORK			$	12,600.00
Structural & Architectural				
Geotech & Foundation Systems		$ 58,000.00		
Building Cost		$ 315,000.00		
Channels & Grit Chamber		$ 70,800.00		
Bridge Cranes and Specialties		$ 100,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	544,000.00
Process Equipment & Piping				
Screens		$ 236,900.00		
Washer / Compactor		$ 51,500.00		
Grit Equipment		$ 231,800.00		
Instrumentation		$ 30,900.00		
Influent Flow Sampler		$ 12,400.00		
Process Gates, Piping, Flow Control, etc.		$ 59,300.00		
Process Pumps		$ 10,300.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	633,100.00
Mechanical				
HVAC		$ 9,000.00		
PLUMBING		$ 5,300.00		
SUBTOTAL: MECHANICAL			$	14,300.00
Electrical				
Electrical / Instrumentation & Controls			$	388,500.00
SUBTOTAL			**$**	**1,704,000.00**
Underdeveloped Design Details	10%		$	170,400.00
Construction Contingencies	15%		$	255,600.00
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$**	**2,130,000.00**

Supporting Costs For
Control Building Construction and Equipment Costs

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	3,300.00		
Excavation & Backfill	$	21,700.00		
SUBTOTAL: SITE WORK			$	7,500.00
Structural & Architectural				
Geotech & Foundation Systems	$	161,000.00		
Building Cost	$	885,600.00		
Furnishing (Lab / office / control room / shop)	$	187,100.00		
Miscelaneous Metal and Stair Fabrications	$	100,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	1,334,000.00
SCADA Control Equipment and Misc. Equipment				
SCADA System	$	327,600.00		
STANDBY GENERATOR AND SWITCH GEAR	$	696,300.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	1,023,900.00
Mechanical				
HVAC	$	18,900.00		
PLUMBING	$	11,100.00		
SUBTOTAL: MECHANICAL			$	9,000.00
Electrical				
Electrical / Instrumentation & Controls			$	5,400.00
TOTAL ESTIMATED PROJECT COST			**$**	**2,379,800.00**

Supporting Costs For
Secondary Treatment and Equipment Costs
(SBR Facility)

CONSTRUCTION COSTS				
General Conditions				
Bonding / Insurance / Project Mgmt. & Admin. / Mobilization			$	1,748,600.00
Site Work				
Land Acquisition		$ 500,000.00		
Site Management / SWPPP		$ 62,600.00		
Headworks		$ 12,600.00		
Control Building		$ -		
SBR		$ 353,900.00		
UV Disinfection		$ 11,000.00		
Digestion & Biosolids		$ 53,900.00		
Site Improvements - (Grading & Site Piping)		$ 194,130.00		
SUBTOTAL: SITE WORK			$	1,188,100.00
Structural & Architectural				
Headworks		$ 544,000.00		
Control Building		$ 1,334,000.00		
SBR		$ 3,400,000.00		
UV Disinfection		$ 274,000.00		
Digestion & Biosolids		$ 1,867,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	7,419,000.00
Process Equipment & Piping				
Headworks		$ 633,100.00		
Control Building		$ 1,023,900.00		
SBR		$ 1,723,700.00		
UV Disinfection		$ 314,819.22		
Digestion & Biosolids		$ 5,234,000.00		
Installation & Start-Up		$ 2,678,900.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	11,608,400.00
Mechanical				
Headworks		$ 14,300.00		
Control Building		$ 9,000.00		
SBR		$ -		
UV Disinfection		$ 9,500.00		
Digestion & Biosolids		$ 26,300.00		
Installation & Start-Up		$ 8,865.00		
SUBTOTAL: MECHANICAL			$	68,000.00
Electrical				
Electrical / Instrumentation & Controls			$	4,696,400.00
SUBTOTAL				
Undeveloped Design Details	10%		*$*	*2,672,900.00*
Construction Contingencies	15%		*$*	*4,009,300.00*
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$**	**33,410,700.00**
NON-CONSTRUCTION COSTS				
SUBTOTAL: Administrative / Engineering / & Legal			**$**	**8,353,000.00**
TOTAL ESTIMATED PROJECT COST			$	41,763,700.00

Supporting Costs For
UV Disinfection Facility

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	1,000.00		
Excavation & Backfill	$	10,000.00		
SUBTOTAL: SITE WORK			$	11,000.00
Structural & Architectural				
Geotech & Foundation Systems	$	31,000.00		
Building Cost	$	202,500.00		
UV Channel Construction	$	10,000.00		
Misc. Metals & Rails	$	30,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	274,000.00
Process Equipment & Piping				
UV Disinfection Equipment	$	252,819.22		
Effluent Composite Sampler	$	12,000.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	264,819.22
Mechanical				
HVAC	$	6,000.00		
PLUMBING	$	3,500.00		
SUBTOTAL: MECHANICAL			$	9,500.00
Electrical				
Electrical / Instrumentation & Controls			$	164,600.00
TOTAL ESTIMATED PROJECT COST			**$**	**723,919.22**

Supporting Costs For
Aerobic Digestion & Biosolids Management Facility

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	2,900.00		
Excavation & Backfill	$	51,000.00		
SUBTOTAL: SITE WORK			$	53,900.00
Structural & Architectural				
Geotech & Foundation Systems	$	244,000.00		
Aerobic Digester Tanks (3)	$	797,100.00		
WAS Holding Tank	$	310,000.00		
Digestion & Biosolids Handling Building	$	463,500.00		
Ladders, Railing, and Misc. Metals.	$	52,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	1,867,000.00
Process Equipment & Piping				
Mechanical Thickening	$	353,800.00		
Digester Feed Pumps	$	44,700.00		
Polymer Feed Pumps	$	47,600.00		
Air Compressors	$	192,100.00		
JET Aeration Headers	$	312,800.00		
Aerobic Digester Mixing Pumps	$	234,200.00		
Fabricated Aluminum Dome Covers	$	540,300.00		
Digested Sludge Transport Pumps	$	35,400.00		
Dewatering Equipment	$	515,000.00		
Piping, Valves, Fittings and Flow Control	$	2,958,100.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	5,234,000.00
Mechanical				
HVAC	$	16,900.00		
PLUMBING	$	9,400.00		
SUBTOTAL: MECHANICAL			$	26,300.00
Electrical				
Electrical / Instrumentation & Controls			$	2,841,600.00
TOTAL ESTIMATED PROJECT COST			**$**	**10,022,800.00**

Alternative T-5B:

Greenfield 5-Stage Bardenpho
with Chemical Phosphorus Removal

Alternative T-5B: Greenfield 5-Stage Bardenpho w/ Chemical Phosphorus Removal
Engineer's Opinion of Probable Construction Cost

CONSTRUCTION COSTS				
General Conditions				
Bonding / Insurance / Project Mgmt & Admin. / Mobilization			$	1,955,400.00
Site Work				
Land Acquisition		$ 500,000.00		
Site Management / SWPPP		$ 79,700.00		
Headworks		$ 12,600.00		
Control Building		$ -		
Bardenpho & Clarifiers		$ 471,600.00		
UV Disinfection		$ 11,000.00		
Digestion & Biosolids		$ 53,900.00		
Site Improvements - (Grading & Site Piping)		$ 247,095.00		
SUBTOTAL: SITE WORK			$	1,375,900.00
Structural & Architectural				
Headworks		$ 544,000.00		
Control Building		$ 1,561,427.56		
Bardenpho & Clarifiers		$ 4,643,000.00		
UV Disinfection		$ 274,000.00		
Digestion & Biosolids		$ 1,867,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	8,889,400.00
Process Equipment & Piping				
Headworks		$ 712,237.50		
Control Building		$ 1,023,900.00		
Bardenpho & Clarifiers		$ 1,988,835.39		
UV Disinfection		$ 211,855.38		
Digestion & Biosolids		$ 5,234,000.00		
Cloth Filtration (P-Removal)		$ 643,000.00		
Installation & Start-Up		$ 2,944,100.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	12,757,900.00
Mechanical				
Headworks		$ 14,300.00		
Control Building		$ 10,530.00		
Bardenpho & Clarifiers		$ -		
UV Disinfection		$ 9,500.00		
Digestion & Biosolids		$ 26,300.00		
Installation & Start-Up		$ 9,094.50		
SUBTOTAL: MECHANICAL			$	69,700.00
Electrical				
Electrical / Instrumentation & Controls			$	4,841,000.00
SUBTOTAL				
Undeveloped Design Details	10%		*$*	*2,988,900.00*
Construction Contingencies	15%		*$*	*4,483,400.00*
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$**	**37,361,600.00**
NON-CONSTRUCTION COSTS				
SUBTOTAL: Administrative / Engineering / & Legal			**$**	**9,341,000.00**
TOTAL ESTIMATED PROJECT COST			$	46,702,600.00

Supporting Costs For
Headworks Construction and Equipment Costs

CONSTRUCTION COSTS				
General Conditions				
Bonding / Insurance / Project Mgmt & Admin / Mobilization			$	111,500.00
Site Work				
Site Prep - Clearing and Grubbing		$ 1,600.00		
Excavation & Backfill		$ 11,000.00		
SUBTOTAL: SITE WORK			$	12,600.00
Structural & Architectural				
Geotech & Foundation Systems		$ 58,000.00		
Building Cost		$ 315,000.00		
Channels & Grit Chamber		$ 70,800.00		
Bridge Cranes and Specialties		$ 100,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	544,000.00
Process Equipment & Piping				
Screens		$ 236,900.00		
Washer / Compactor		$ 51,500.00		
Grit Equipment		$ 231,800.00		
Instrumentation		$ 30,900.00		
Influent Flow Sampler		$ 12,400.00		
Process Gates, Piping, Flow Control, etc.		$ 59,300.00		
Process Pumps		$ 10,300.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	633,100.00
Mechanical				
HVAC		$ 9,000.00		
PLUMBING		$ 5,300.00		
SUBTOTAL: MECHANICAL			$	14,300.00
Electrical				
Electrical / Instrumentation & Controls			$	388,500.00
SUBTOTAL			**$**	**1,704,000.00**
Underdeveloped Design Details	10%		$	170,400.00
Construction Contingencies	15%		$	255,600.00
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$**	**2,130,000.00**

Supporting Costs For
Control Building Construction and Equipment Costs

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	3,300.00		
Excavation & Backfill	$	21,700.00		
SUBTOTAL: SITE WORK			$	7,500.00
Structural & Architectural				
Geotech & Foundation Systems	$	161,000.00		
Building Cost	$	885,600.00		
Furnishing (Lab / office / control room / shop)	$	187,100.00		
Miscelaneous Metal and Stair Fabrications	$	100,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	1,334,000.00
SCADA Control Equipment and Misc. Equipment				
SCADA System	$	327,600.00		
STANDBY GENERATOR AND SWITCH GEAR	$	696,300.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	1,023,900.00
Mechanical				
HVAC	$	18,900.00		
PLUMBING	$	11,100.00		
SUBTOTAL: MECHANICAL			$	9,000.00
Electrical				
Electrical / Instrumentation & Controls			$	5,400.00
TOTAL ESTIMATED PROJECT COST			**$**	**2,379,800.00**

Supporting Costs For
Secondary Treatment and Equipment Costs
(5-Stage Bardenpho w/ Chemical Phosphorus Removal)

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	38,600.00		
Excavation & Backfill	$	433,000.00		
SUBTOTAL: SITE WORK			$	471,600.00
Structural & Architectural				
Geotech & Foundation Systems	$	606,000.00		
Bardenpho Basins & Clarifiers	$	3,776,000.00		
Ladders, Railing, and Misc. Metals.	$	261,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	4,643,000.00
Process Equipment & Piping				
Air Compressors	$	571,250.57		
Air Diffusion Equipment	$	119,684.42		
Submersible Mixers	$	405,306.93		
Internal Recycle Pumps	$	31,116.65		
Control System	$	85,339.45		
Instrumentation	$	24,333.94		
Spare Parts	$	5,600.26		
Spare Pumps	$	17,067.46		
Flow Control & Process Gates	$	260,400.00		
Chemical Feed	$	78,735.71		
Secondary Clarifier Equipment	$	390,000.00		
Cloth Filtration (P-Removal)	$	643,000.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	2,631,835.39
Mechanical				
HVAC	$	-		
PLUMBING	$	-		
SUBTOTAL: MECHANICAL			$	-
Electrical				
Electrical / Instrumentation & Controls			$	724,000.00
TOTAL ESTIMATED PROJECT COST			$	8,470,435.39

Supporting Costs For
UV Disinfection Facility

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	1,000.00		
Excavation & Backfill	$	10,000.00		
SUBTOTAL: SITE WORK			$	11,000.00
Structural & Architectural				
Geotech & Foundation Systems	$	31,000.00		
Building Cost	$	202,500.00		
UV Channel Construction	$	10,000.00		
Misc. Metals & Rails	$	30,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	274,000.00
Process Equipment & Piping				
UV Disinfection Equipment	$	252,819.22		
Effluent Composite Sampler	$	12,000.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	264,819.22
Mechanical				
HVAC	$	6,000.00		
PLUMBING	$	3,500.00		
SUBTOTAL: MECHANICAL			$	9,500.00
Electrical				
Electrical / Instrumentation & Controls			$	164,600.00
TOTAL ESTIMATED PROJECT COST			**$**	**723,919.22**

Supporting Costs For
Aerobic Digestion & Biosolids Management Facility

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	2,900.00		
Excavation & Backfill	$	51,000.00		
SUBTOTAL: SITE WORK			$	53,900.00
Structural & Architectural				
Geotech & Foundation Systems	$	244,000.00		
Aerobic Digester Tanks (3)	$	797,100.00		
WAS Holding Tank	$	310,000.00		
Digestion & Biosolids Handling Building	$	463,500.00		
Ladders, Railing, and Misc. Metals.	$	52,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	1,867,000.00
Process Equipment & Piping				
Mechanical Thickening	$	353,800.00		
Digester Feed Pumps	$	44,700.00		
Polymer Feed Pumps	$	47,600.00		
Air Compressors	$	192,100.00		
JET Aeration Headers	$	312,800.00		
Aerobic Digester Mixing Pumps	$	234,200.00		
Fabricated Aluminum Dome Covers	$	540,300.00		
Digested Sludge Transport Pumps	$	35,400.00		
Dewatering Equipment	$	515,000.00		
Piping, Valves, Fittings and Flow Control	$	2,958,100.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	5,234,000.00
Mechanical				
HVAC	$	16,900.00		
PLUMBING	$	9,400.00		
SUBTOTAL: MECHANICAL			$	26,300.00
Electrical				
Electrical / Instrumentation & Controls			$	2,841,600.00
TOTAL ESTIMATED PROJECT COST			**$**	**10,022,800.00**

Alternative T-5C:

Greenfield MBR Facility

Alternative T-5C: Greenfield MBR Facility
Engineer's Opinion of Probable Construction Cost

CONSTRUCTION COSTS				
General Conditions				
Bonding / Insurance / Project Mgmt & Admin. / Mobilization			$	2,090,600.00
Site Work				
Land Acquisition		$ 400,000.00		
Site Management / SWPPP		$ 79,200.00		
Headworks		$ 12,600.00		
Control Building		$ -		
MBR		$ 468,300.00		
UV Disinfection		$ 11,000.00		
Digestion & Biosolids		$ 53,900.00		
Site Improvements - (Grading & Site Piping)		$ 245,610.00		
SUBTOTAL: SITE WORK			$	1,270,600.00
Structural & Architectural				
Headworks		$ 544,000.00		
Control Building		$ 1,334,000.00		
MBR		$ 3,981,000.00		
UV Disinfection		$ 274,000.00		
Digestion & Biosolids		$ 1,867,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	8,000,000.00
Process Equipment & Piping				
Headworks		$ 712,237.50		
Control Building		$ 1,023,900.00		
MBR		$ 3,889,800.00		
UV Disinfection		$ 238,337.30		
Digestion & Biosolids		$ 5,234,000.00		
Installation & Start-Up		$ 3,329,500.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	14,427,800.00
Mechanical				
Headworks		$ 14,300.00		
Control Building		$ 9,000.00		
MBR		$ 144,100.00		
UV Disinfection		$ 9,500.00		
Digestion & Biosolids		$ 26,300.00		
Installation & Start-Up		$ 30,480.00		
SUBTOTAL: MECHANICAL			$	233,700.00
Electrical				
Electrical / Instrumentation & Controls			$	5,933,200.00
SUBTOTAL			**$**	**31,955,900.00**
Undeveloped Design Details	10%		*$*	*3,195,600.00*
Construction Contingencies	15%		*$*	*4,793,400.00*
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$**	**39,944,900.00**
NON-CONSTRUCTION COSTS				
SUBTOTAL: Administrative / Engineering / & Legal			**$**	**9,987,000.00**
TOTAL ESTIMATED PROJECT COST			$	49,931,900.00

Supporting Costs For
Headworks Construction and Equipment Costs

CONSTRUCTION COSTS				
General Conditions				
Bonding / Insurance / Project Mgmt & Admin / Mobilization			$	111,500.00
Site Work				
Site Prep - Clearing and Grubbing		$ 1,600.00		
Excavation & Backfill		$ 11,000.00		
SUBTOTAL: SITE WORK			$	12,600.00
Structural & Architectural				
Geotech & Foundation Systems		$ 58,000.00		
Building Cost		$ 315,000.00		
Channels & Grit Chamber		$ 70,800.00		
Bridge Cranes and Specialties		$ 100,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	544,000.00
Process Equipment & Piping				
Screens		$ 236,900.00		
Washer / Compactor		$ 51,500.00		
Grit Equipment		$ 231,800.00		
Instrumentation		$ 30,900.00		
Influent Flow Sampler		$ 12,400.00		
Process Gates, Piping, Flow Control, etc.		$ 59,300.00		
Process Pumps		$ 10,300.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	633,100.00
Mechanical				
HVAC		$ 9,000.00		
PLUMBING		$ 5,300.00		
SUBTOTAL: MECHANICAL			$	14,300.00
Electrical				
Electrical / Instrumentation & Controls			$	388,500.00
SUBTOTAL			**$**	**1,704,000.00**
Underdeveloped Design Details	10%		$	170,400.00
Construction Contingencies	15%		$	255,600.00
SUBTOTAL: ESTIMATED CONSTRUCTION COST			**$**	**2,130,000.00**

Supporting Costs For
Control Building Construction and Equipment Costs

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	3,300.00		
Excavation & Backfill	$	21,700.00		
SUBTOTAL: SITE WORK			$	7,500.00
Structural & Architectural				
Geotech & Foundation Systems	$	161,000.00		
Building Cost	$	885,600.00		
Furnishing (Lab / office / control room / shop)	$	187,100.00		
Miscelaneous Metal and Stair Fabrications	$	100,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	1,334,000.00
SCADA Control Equipment and Misc. Equipment				
SCADA System	$	327,600.00		
STANDBY GENERATOR AND SWITCH GEAR	$	696,300.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	1,023,900.00
Mechanical				
HVAC	$	18,900.00		
PLUMBING	$	11,100.00		
SUBTOTAL: MECHANICAL			$	9,000.00
Electrical				
Electrical / Instrumentation & Controls			$	5,400.00
TOTAL ESTIMATED PROJECT COST			**$**	**2,379,800.00**

Supporting Costs For
Secondary Treatment and Equipment Costs
(MBR Facility)

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	12,300.00		
Excavation & Backfill	$	456,000.00		
SUBTOTAL: SITE WORK			$	468,300.00
Structural & Architectural				
Geotech & Foundation Systems	$	520,000.00		
Concrete Basins	$	2,200,000.00		
MBR Building Costs	$	1,000,000.00		
Ladders, Railing, and Misc. Metals.	$	261,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	3,981,000.00
Process Equipment & Piping				
Membrane Bio Reactor System	$	2,812,800.00		
Membrane Equipment				
Permeate Pumping				
Backpulse System				
Membrane Air Scour				
RAS Pumps & Appurtanences				
Biological Equipment				
Membrane Cleaning System				
Process Chemical Dosing System				
Compressed Air System				
Electrical & Control Equipment				
Process Gates / Piping / Control	$	180,000.00		
Air Compressors	$	699,000.00		
Motorized Bridge Crane	$	198,000.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	3,889,800.00
Mechanical				
HVAC	$	119,100.00		
PLUMBING	$	25,000.00		
SUBTOTAL: MECHANICAL			$	144,100.00
Electrical				
Electrical / Instrumentation & Controls			$	1,998,000.00
TOTAL ESTIMATED CONSTRUCTION COST			**$**	**10,481,200.00**

Supporting Costs For
UV Disinfection Facility

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	1,000.00		
Excavation & Backfill	$	10,000.00		
SUBTOTAL: SITE WORK			$	11,000.00
Structural & Architectural				
Geotech & Foundation Systems	$	31,000.00		
Building Cost	$	202,500.00		
UV Channel Construction	$	10,000.00		
Misc. Metals & Rails	$	30,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	274,000.00
Process Equipment & Piping				
UV Disinfection Equipment	$	252,819.22		
Effluent Composite Sampler	$	12,000.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	264,819.22
Mechanical				
HVAC	$	6,000.00		
PLUMBING	$	3,500.00		
SUBTOTAL: MECHANICAL			$	9,500.00
Electrical				
Electrical / Instrumentation & Controls			$	164,600.00
TOTAL ESTIMATED PROJECT COST			**$**	**723,919.22**

Supporting Costs For
Aerobic Digestion & Biosolids Management Facility

CONSTRUCTION COSTS				
Site Work				
Site Prep - Clearing and Grubbing	$	2,900.00		
Excavation & Backfill	$	51,000.00		
SUBTOTAL: SITE WORK			$	53,900.00
Structural & Architectural				
Geotech & Foundation Systems	$	244,000.00		
Aerobic Digester Tanks (3)	$	797,100.00		
WAS Holding Tank	$	310,000.00		
Digestion & Biosolids Handling Building	$	463,500.00		
Ladders, Railing, and Misc. Metals.	$	52,000.00		
SUBTOTAL: STRUCTURAL & ARCHITECTURAL			$	1,867,000.00
Process Equipment & Piping				
Mechanical Thickening	$	353,800.00		
Digester Feed Pumps	$	44,700.00		
Polymer Feed Pumps	$	47,600.00		
Air Compressors	$	192,100.00		
JET Aeration Headers	$	312,800.00		
Aerobic Digester Mixing Pumps	$	234,200.00		
Fabricated Aluminum Dome Covers	$	540,300.00		
Digested Sludge Transport Pumps	$	35,400.00		
Dewatering Equipment	$	515,000.00		
Piping, Valves, Fittings and Flow Control	$	2,958,100.00		
SUBTOTAL: EQUIPMENT & FURNISHINGS			$	5,234,000.00
Mechanical				
HVAC	$	16,900.00		
PLUMBING	$	9,400.00		
SUBTOTAL: MECHANICAL			$	26,300.00
Electrical				
Electrical / Instrumentation & Controls			$	2,841,600.00
TOTAL ESTIMATED PROJECT COST			**$**	**10,022,800.00**

Biosolids Calculations

Waste Activated Sludge Biosolids Production

Terms & Abbreviations:

- WAS Waste Activated Sludge
- BOD Biological Oxygen Demand

Solids Production Ralated to BOD Loading:

$$W_s = K \cdot BOD$$

$$W_s = Biological\ sludge\ solids, lbs\ of\ dry\ weight\ per\ day$$
$$K = Fraction\ of\ applied\ BOD\ as\ excess\ biological\ solids\ from\ Figure\ 11-46$$
$$BOD = BOD\ in\ applied\ wastewater\ after\ primary\ sedimentation, lb/day$$

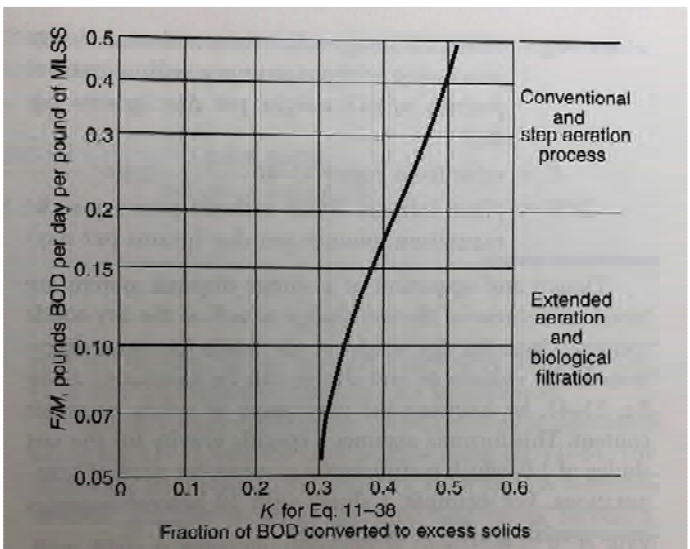

FIGURE 11–46 Hypothetical relationship between food-to-microorganism ratio and coefficient K in Eq. 11–38 for calculating excess activated-sludge production in biological aeration of wastewater, based on an effluent suspended solids of approximately 30 mg/l.

Ffrom Water & Wastewater Technology, 7th Edition - by Hammer & Hammer

$$W_s = K \cdot BOD$$

$$W_s = 0.35 \cdot 6961\ lb/day$$

$$W_s = 4{,}872\ lb/day$$

Aerobic Digestion Aeration Requirements

VOLUME OF SLUDGE PRODUCED PER DAY (GALLONS)		
Solids Content	0.75	%
V (Gallons/day)	77,910.00	gal
Digester SRT	45	days
Digester Volume	3,505,950.00	gal
V (Gallons/wk)	545,370.00	gal
Thickening Cycles / Week	3	cycles
V/cycle	181,790.00	
Hours per Cycle	6	hrs
Thickening Feed Rate	505	gpm
Thickening Unit Rating	450	gpm

VOLUME OF THICKENED SLUDGE		
Solids Content	3.5	%
V (Gallons/day)	16700	
SRT	45	
Digester Volume	751,500	gal

Digester Aeration Requirements	
lb O2 / lb VS reduced	2.3
Pounds TSS (LBS)	4873
% Volitile	75%
Pounds VSS (lbs)	3655
% Reduction	20%
LB VSS Reduced	730.91
lb O2 - Actual	1,681.08
SOR/AOR Estimate	1.82
Standard Oxygen Demand	3,059.57
Aeration Time / Day	20.00
O2/hr	152.98
No. Tanks	800.00
O2 / hr / digester	0.19
lb O2/lb-air	0.23
Clean Water Eff.	26%
SCFM/basin	0.71
TOTAL SCFM	2.13

Facultative Biosolids Storage Lagoon - Sludge Volume Production

Terms & Abbreviations:

- WAS Waste Activated Sludge
- VSS Volatile Suspended Solids
- nVSS non-Volatile Suspended Solids
- TSS Total Suspended Solids
- SD Solids Destruction
- FL Facultative Lagoon
- gpd Gallons per Day
- MG Million Gallons
- $\dot{M}_{6\%}$ $Mass\ of\ Biosolids\ @\ 6\%\ Solids\ Concentration$

Assumptions & Parameters:

- WAS Production Rate: 4872 lb/day
  - See WAS Biosolids Production
- VSS = 75% of TSS
- VSS_SD = 20%
- Solids Concentration of Settled Sludge = 6%
  - See Metcalf & Eddy

Mass of VSS:

$$VSS = 0.75\ \cdot 4872\ lb/day$$
$$VSS = 3{,}654\ lb/day$$

$$nVSS = 1{,}218\ lbs/day$$

Volatile Solids Destruction:

$$3{,}654\,\frac{lb}{day} \cdot 0.20\ [SD] = 730.8\ lb/day$$
$$3{,}654\,\frac{lb}{day} - 730.8\,\frac{lb}{day} = 2{,}923.2\,\frac{lb}{day}\,(remaining)$$

Total Solids Accumulation Per Day:

$$2{,}923.2\ \frac{lb-VSS}{day} + 1218\ \frac{lb-nVSS}{day} = 4{,}141.2\ \frac{lb-TSS}{day}$$

Sludge Volume @ 6% Solids Concentration:

$$\frac{4{,}141.2\ lb-TSS}{\dot{M}_{6\%}} = \frac{6\%}{100\%}$$

$$\dot{M}_{6\%} = 8{,}246\ gpd \qquad \dot{M}_{6\%} \cdot 365\,\frac{day}{yr} = 3.01\ MG/yr$$

Solids Loading Rate in Facultative Biosolids Storage Lagoon

$$VSS = 3{,}654 \frac{lb}{day}$$

Area of Facultative Storage Lagoons:

$$FL_1 = 7\ acres \mid FL_2 = 7\ acres$$

$$FL_1 + FL_2 = 14\ acres\ \cdot 43{,}560 \frac{ft^2}{acre} = 6.09x10^5 ft^2$$

$$Solids\ Loading\ Rate = \frac{lbVSS}{Surface\ Area} = \frac{3{,}654\ lb/day}{6.09\ x10^5 ft^2} = \frac{6\ lbVSS}{1000\ ft^2 \cdot day}$$

NOTE: If facultative storage lagoons are not loaded too heavily ($\leq 20\ lbVSS/1000ft^2 \cdot day$)*, aerobic surface layers can be maintained through atmospheric reaeration. Given the calculated solids loading rate falls below this value, an aerobic layer on this facultative lagoon should be easily achievable (Metcalf & Eddy). However, due to the proximity to residential areas and the existing nuisance odor complaints the City of Belgrade is already experiencing, surface aerators have been accounted for to ensure an aerobic water layer is maintained on the facultative lagoons to further control nuisance odors.*

Storage Capacity of Pond 1 & Pond 2

Assumptions:

- Maximum Depth of Pond 1 and 2 = 10 ft
- Max Operating Depth of Settled Solids = 5 ft

$$FL_1 = FL_2 = 7\ acres$$

Max Sludge Volume Capacity of Each Pond @ 6% Solids

$$7\ acres\ \cdot 43{,}560\ \frac{ft^2}{acre}\ \cdot 5\ ft = 1.5x10^6 ft^3$$

$$1.5x10^6 ft^3\ \cdot 7.481\ \frac{gal}{ft^3} = 11.4x10^6\ gal$$

Time to Reach Max Sludge Volume Capacity of Each Pond:

$$\frac{Max\ Sludge\ Volume}{Volume\ per\ Year} = \frac{11.4x10^6\ gal}{3.01x10^6\ gal/yr} \sim 7.5\ yrs\ per\ each\ basin$$

ALTERNATIVE D-1
SUPPORTING DOCUMENTS

Belgrade Wastewater Master Plan
Alternative D-1
Estimated IP Beds A & B Existing Available Flow Rates

Pump IP -1
Nominal Capacity= 1400 gpm Chapter 4 shows pump operates close to design point

Historical, pump has operated on monthly average of about 2 hr/day

	Wetting	Drying	
Summer	3	5	days
Winter	3	10	days

To discharge to IP Beds A and B in the summer, treated wastewater will be pumped to Bed A for 3 days, then Bed B for 3 days, then off for 2 day, repeat

To discharge to IP Beds A and B in the winter, treated wastewater will be pumped to Bed A for 3 days, then Bed B for 3 days, then off for 7 days, repeat

Percent of on/off time

summer	75%	on
winter	46%	on

Estimated Monthly Average Pump Times

Summer	18.0	hr/day
Winter	11.1	hr/day

Estimated monthly average day flow rates though transmission main

Summer	1,512,000	gpd
Winter	930,462	gpd

Estimated monthly average day flow rates to each IP Bed

	IP Bed A	IP Bed B	
Summer	756,000	756,000	gpd
Winer	465,231	465,231	gpd

** Calculations preformed for the hydraulic capacity of the IP Beds estimate IP Beds A and Be can handle 362,541 gpd in the winter months and 589,129 gpd in the summer months. Therefore, the hydraulic capacity of the IP Bed limits the allowable discharge rate, not the hydraulic capacity of the existing pumps and piping

Belgrade Wastewater Master Plan
Alternative D-1
Estimated IP Bed C Existing Available Flow Rates

Pump IP -2
Nominal Capacity= 1400 gpm Chapter 4 shows pump operates close to design point

Historical, pump has operated on monthly average of about 2.5 hr/day

	Wetting	Drying	
Summer	3	5	days
Winter	3	10	days

To discharge to IP Beds C in the summer, treated wastewater will be pumped to Bed C for 3 days, 5 days of drying, repeat

To discharge to IP Beds C in the winter, treated wastewater will be pumped to Bed C for 3 days, 10 days of drying, repeat

Percent of on/off time

summer	38%	on
winter	23%	on

Estimated Monthly Average Pump Times

Summer	9.0	hr/day
Winter	5.5	hr/day

Estimated monthly average day flow rates to Bed C

Summer	756,000	gpd
Winter	465,231	gpd

** Calculations preformed for the hydraulic capacity of the IP Beds estimates IP Beds C can handle 362,541 gpd in the winter months and 589,129 gpd in the summer months. Therefore, the hydraulic capacity of the IP Bed limits the allowable discharge rate, not the hydraulic capacity of the existing pumps and piping

Belgrade Wastewater Master Plan
Alternative D-1
Estimated Irrigation System Existing Available Flow Rates

Design Agronomic Rates

Month	Rate Inches	% of average
May	6.73	61%
June	13.73	124%
July	19.11	172%
August	17.76	160%
September	9.15	83%
October	0.00	0%
Annual	66.48	

Existing Agronomic Rates (as calculated by Morrison Maierle, Inc.)

Month	Rate Inches	% of average
May	3.50	60%
June	7.00	121%
July	10.10	174%
August	9.40	162%
September	4.80	83%
October	0.00	0%
Annual	34.80	

*Increase in Agronomic rates due to decreased design TN concentration

Percent increase in Rates: 191%

Average monthly run time (for summer months) for existing system: 9.94 hr/day

Estimated Design Run Time: 18.99 hr/day

Pump Nominal Capacity: 1200 gpm

*analysis in chapter 4 shows actual flow rates measured in the SCADA system are roughly 25% lower then theoretical flow rates based on pump run times

Estimated flow rate in summer months (based on pump run time): 1,367,196 gpd

Estimated average flow rate: 1,025,397 gpd

Month	Flow Rate gpd	Required pump run time (hr/day)	Design Pump Run Time (hr/day)	Design Flow Rate gpd
May	622,827	11.5	11.5	622,827
June	1,270,640	23.5	12.0	648,000
July	1,768,532	32.8	12.0	648,000
August	1,643,596	30.4	12.0	648,000
September	846,785	15.7	12.0	648,000
October	0	0	0	0
Average	1,025,397			

* Pump run times modified to not exceed 12 hr/day

Belgrade Wastewater Master Plan
Alternative D-1
Water Balance

*Assumes The IP Loading Limits are based on Average Day rather than max day

		IN				OUT										Δ Storage	Cummulative Storage
Month	Days	Design Flow	Precipitation			IP Bed A		IP Bed B		IP Bed C	Land Application			Evaportation			
		(gpd)	(gal)	(inches)	(gal)	(gal)	(gpd)	(gal)	(gpd)	(gal)	(gpd)	(gpd)	(gal)	(inches)	(gallons)	(gal)	(gal)
January	31	1,381,563	42,828,447	0.07	56,647	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541					9,168,803	38,215,030
February	28	1,381,563	38,683,758	0.27	218,497	10,151,142	362,541	10,151,142	362,541	10,151,142	362,541					8,448,831	46,663,861
March	31	1,381,563	42,828,447	0.71	574,567	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541					9,686,722	56,350,583
April	30	1,381,563	41,446,884	1.60	1,294,800	17,673,863	589,129	17,673,863	589,129	17,673,863	589,129			2.34	1,892,026	-12,171,930	44,178,653
May	31	1,381,563	42,828,447	1.73	1,400,002	18,262,991	589,129	18,262,991	589,129	9,426,060	589,129	622,826.7	9,342,400	3.91	3,160,929	-14,226,924	29,951,730
June	30	1,381,563	41,446,884	2.99	2,419,657	17,673,863	589,129	17,673,863	589,129	0	0	648,000.0	9,720,000	4.22	3,415,843	-4,617,028	25,334,702
July	31	1,381,563	42,828,447	2.41	1,950,292	18,262,991	589,129	18,262,991	589,129	0	0	648,000.0	9,720,000	5.84	4,724,400	-6,191,644	19,143,058
August	31	1,381,563	42,828,447	1.01	817,342	18,262,991	589,129	18,262,991	589,129	0	0	648,000.0	9,720,000	5.02	4,061,624	-6,661,818	12,481,241
September	30	1,381,563	41,446,884	3.17	2,565,322	17,673,863	589,129	17,673,863	589,129	8,836,931	589,129	648,000.0	9,720,000	3.20	2,588,790	-12,481,241	-
October	31	1,381,563	42,828,447	1.57	1,270,522	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541	0	0	1.83	1,484,164	8,898,513	8,898,513
November	30	1,381,563	41,446,884	1.64	1,327,169	10,876,223	362,541	10,876,223	362,541	10,876,223	362,541					10,145,384	19,043,897
December	31	1,381,563	42,828,447	1.10	890,175	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541					10,002,330	29,046,227

Land Application area=	117	acres	Lagoon Water Surface Area			% of Agro Rates	100%
	5,096,520	sf	Total Treatment	14 acres	609,840 SF		
			Storage	15.8 acres	688,248 SF		
			Total	29.8 acres	1,298,088 SF		

Cumulative Storage is the amount of water in the lagoons at the end of the month
The system does not discharge to IP bed C and the irrigation system simultaneously

Belgrade Wastewater Master Plan
Alternative D-1
Flow Projections

Year	Populations	Wastewater Production Rate	Flow (gpd)	
2010	7,389	86	635,454	
2011	7,648	86	657,695	
2012	7,915	86	680,714	
2013	8,192	86	704,539	
2014	8,479	86	729,198	
2015	8,776	86	754,720	
2016	9,083	86	781,135	
2017	9,401	86	808,475	
2018	9,730	86	836,772	
2019	10,070	86	866,059	
2020	10,423	86	896,371	
2021	10,788	86	927,744	
2022	11,165	86	960,215	
2023	11,556	86	993,822	
2024	11,961	86	1,028,606	
2025	12,379	86	1,064,607	
2026	12,812	86	1,101,868	
2027	13,261	86	1,140,434	
2028	13,725	86	1,180,349	
2029	14,205	86	1,221,661	10% safety factor
2030	14,703	86	1,264,419	
2031	15,217	86	1,308,674	
2032	15,750	86	1,354,478	
2033	16,301	86	1,401,884	
2034	16,872	86	1,450,950	
2035	17,462	86	1,501,733	
2036	18,073	86	1,554,294	
2037	18,706	86	1,608,694	
2038	19,360	86	1,664,999	

ALTERNATIVE D-3
SUPPORTING DOCUMENTS

NON-DEG ANALYSIS

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

NITRATE SENSITIVITY ANALYSIS

SITE NAME: Belgrade WWTP
COUNTY: Gallatin
LOT #: Outfall 002-B
NOTES:

VARIABLES	DESCRIPTION	VALUE	UNITS
K	Hydraulic Conductivity	1000.00	ft/day
I	Hydraulic Gradient	0.0044	ft/ft
D	Mixing Zone Thickness (usually constant)	15.0	ft
L	Mixing Zone Length (see ARM 17.30.517(1)(d)(viii)	500	ft
Y	Width of Drainfield Perpendicular to Ground Water Flow	780	ft
Ng	Background Nitrate (as Nitrogen) Concentration	1.80	mg/L
Nr	Nitrate (as Nitrogen) Concentration in Precipitation (usually constant)	1.0	mg/L
Ne	Nitrate (as Nitrogen) Concentration in Effluent	13.50	mg/L
#l	Number of Single Family Homes on the Drainfield	1.0	
Ql	Quantity of Effluent per Single Family Home	42,221.94	ft3/day
P	Precipitation	14.0	in/year
V	Percent of Precipitation Recharging Ground Water (usually constant)	0.20	
EQUATIONS			
W	Width of Mixing Zone Perpendicular to Ground Water Flow = (0.175)(L)+(Y)	867.50	ft
Am	Cross Sectional Area of Aquifer Mixing Zone = (D)(W)	13012.50	ft2
As	Surface Area of Mixing Zone = (L)(W)	433750.00	ft2
Qg	Ground Water Flow Rate = (K)(I)(Am)	57255.00	ft3/day
Qr	Recharge Flow Rate = (As)(P/12/365)(V)	276.29	ft3/day
Qe	Effluent Flow Rate = (#l)(Ql)	42221.94	ft3/day
SOLUTION			
Nt	**Nitrate (as Nitrogen) Concentration at End of Mixing Zone =((Ng)(Qg)+(Nr)(Qr)+(Ne)(Qe)) / ((Qg)+(Qr)+(Qe))**	**6.75**	**mg/L**
	Target Concentration=6.75 mg/l (90% of 7.5mg/l)		

BY:
DATE: June 7, 2017

REV. 03/2005

Blegrade Wastewater Master Plan
Treatment and Disposal
IP Bed D Loading
TD&H Job No. B16-048

Design By: NMR

IP Bed D Design Calculations

*Assumed IP Bed wet:dry ratio is 1:1
DENOTES USER INPUT

Infiltration Rate
(from infiltrometer tests performed for 2004 Design Report)

Infiltration Rate= **0.25** inches/min

DEQ-2 recommends using 7 to 10% of measured infiltration rate for Basin Flooding Test
Adjusted Infiltration Rate= 0.0175 inches/min
2.1 feet per day

IP Bed Construction

Number of IP Beds=	**3**	Cell Width=	**100**	feet
Number of Cells per IP Bed=	**5**	Cell Length=	**200**	feet
		Cell Area=	20,000	SF

Allowable Hydraulic Loading

Flow Rate= 314,202 gpd per cell
1,571,010 gpd per IP Bed

Permit Hydraulic Limits

*According to non deg analysis, assuming 7.5 mg/l TN allowed at the end of the mixing zone

Allowable Flow= 355,526 gpd

IP Loading Cycle

DEQ-2 Recommended Cycles

	Application Period	Drying Period
Summer	1-3 days	4-5 days
Winter	1-3 days	5-10 days

Month	Season	IP Bed A	
		(gpd)	(ppd)
January	Winter	362,541	40.9
February	Winter	362,541	40.9
March	Winter	362,541	40.9
April	Summer	589,129	66.5
May	Summer	589,129	66.5
June	Summer	589,129	66.5
July	Summer	589,129	66.5
August	Summer	589,129	66.5
September	Summer	589,129	66.5
October	Winter	362,541	40.9
November	Winter	362,541	40.9
December	Winter	362,541	40.9
	Annual	475,835	53.7

Belgrade Wastewater Master Plan
Alternative D-3
IP Bed D Water Balance

*Assumes The IP Loading Limits are based on Average Day rather than max day

Month	Days	IN				OUT													
		Design Flow		Precipitation		IP Bed A		IP Bed B		IP Bed C		IP Bed D		Land Application		Evaporation		Δ Storage	Cumulative Storage
		(gpd)	(gal)	(inches)	(gal)	(gal)	(gpd)	(gal)	(gpd)	(gal)	(gpd)	(gal)	(gpd)	(in)	(gal)	(inches)	(gallons)	(gal)	(gal)
January	31	1,670,000	51,770,000	0.07	56,647	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541	6,932,812	223,639					11,177,544	46,185,196
February	28	1,670,000	46,760,000	0.27	218,497	10,151,142	362,541	10,151,142	362,541	10,151,142	362,541	6,261,895	223,639					10,263,178	56,448,374
March	31	1,670,000	51,770,000	0.71	574,567	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541	6,932,812	223,639					11,695,464	68,143,838
April	30	1,670,000	50,100,000	1.60	1,294,800	17,673,863	589,129	17,673,863	589,129	17,673,863	589,129	6,709,173	223,639			2.34	1,892,026	-10,227,987	57,915,851
May	31	1,670,000	51,770,000	1.73	1,400,002	18,262,991	589,129	18,262,991	589,129	18,262,991	589,129	6,932,812	223,639		0	3.91	3,160,929	-11,712,713	46,203,138
June	30	1,670,000	50,100,000	2.99	2,419,657	17,673,863	589,129	17,673,863	589,129	17,673,863	589,129	6,709,173	223,639		0	4.22	3,415,843	-10,626,947	35,576,191
July	31	1,670,000	51,770,000	2.41	1,950,292	18,262,991	589,129	18,262,991	589,129	18,262,991	589,129	6,932,812	223,639		0	5.84	4,724,400	-12,725,894	22,850,297
August	31	1,670,000	51,770,000	1.01	817,342	18,262,991	589,129	18,262,991	589,129	18,262,991	589,129	6,932,812	223,639		0	5.02	4,061,624	-13,196,068	9,654,229
September	30	1,670,000	50,100,000	3.17	2,565,322	17,673,863	589,129	17,673,863	589,129	17,673,863	589,129	6,709,173	223,639		0	3.20	2,588,790	-9,654,229	-
October	31	1,670,000	51,770,000	1.57	1,270,522	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541	6,932,812	223,639			1.83	1,484,164	10,907,254	10,907,254
November	30	1,670,000	50,100,000	1.64	1,327,169	10,876,223	362,541	10,876,223	362,541	10,876,223	362,541	6,709,173	223,639					12,089,327	22,996,582
December	31	1,670,000	51,770,000	1.10	890,175	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541	6,932,812	223,639					12,011,071	35,007,652

Non deg analysis allows for 316,664 gpd to maintain 6.75 mg/l TN (90% of 7.5 mg/l) at the end of mixing zone

Land Application area= 117 acres
5,096,520 sf

Cumulative Storage is the amount of water in the lagoons at the end of the month

Lagoon Water Surface Area

Total Treatment	14 acres	609,840 SF
Storage	15.8 acres	688,248 SF
Total	29.8 acres	1,298,088 SF

Belgrade Wastewater Master Plan
Alternative D-3
Estimated Utility Costs

Summer			Winter			Annual		
Pump IP-1			Pump IP-1			Pump IP-1		
Motor Horse Power=	40	HP	Motor Horse Power=	40	HP			
	29828	W		29828	W			
	29.828	kW		29.828	kW			
Assumed Pump Run Time=	14	hr/day	Assumed Pump Run Time=	8.6	hr/day			
Daily Energy Requirement=	417.592	kW-hr	Daily Energy Requirement=	256.521	kW-hr			
Sumer Energy Requirement=	76419.3	kw-hr	Winter Energy Requirement=	46686.8	kw-hr	Annual Energy Requirements	123106.1	kW-hr
Electricity Cost=	0.1	$/kW-hr	Electricity Cost=	0.1	$/kW-hr			
Total Daily Pump IP-1Cost	$42		Total Daily Pump IP-1 Cost	$26		Annual Pump IP-1 Cost	$12,311	
Summer Pump IP-1 Cost	$7,642		Winter Pump IP-1 Cost	$4,669				
Pump IP-2			Pump IP-2			Pump IP-2		
Motor Horse Power=	40	HP	Motor Horse Power=	40	HP			
	29828	W		29828	W			
	29.828	kW		29.828	kW			
Assumed Pump Run Time=	7	hr/day	Assumed Pump Run Time=	9.7	hr/day			
Daily Energy Requirement=	208.796	kW-hr	Daily Energy Requirement=	289.332	kW-hr			
Summer Energy Requirement=	38209.7	kw-hr	Summer Energy Requirement=	52658.4	kw-hr	Annual Energy Requirements	90868.02	kW-hr
Electricity Cost=	0.1	$/kW-hr	Electricity Cost=	0.1	$/kW-hr			
Total Daily Pump IP-2 Cost	$21		Total Daily Pump IP-2 Cost	$29		Annual Pump IP-2 Cost	$9,087	
Summer Pump IP-2 Cost	$3,821		Summer Pump IP-2 Cost	$5,266				
						Total Annual Pump Utilities C	**$21,397**	

ALTERNATIVE D-4
SUPPORTING DOCUMENTS

Belgrade Wastewater Master Plan
Alternative D-4
Water Balance

*Assumes The IP Loading Limits are based on Average Day rather than max day

Month	Days	IN				OUT											
		Design Flow		Precipitation		IP Bed A		IP Bed B		IP Bed C		Land Application		Evaporation		Δ Storage	Cumulative Storage
		(gpd)	(gal)	(inches)	(gal)	(gal)	(gpd)	(gal)	(gpd)	(gal)	(gpd)	(in)	(gal)	(inches)	(gallons)	(gal)	(gal)
January	31	1,670,000	51,770,000	0.07	56,647	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541					18,110,356	73,692,806
February	28	1,670,000	46,760,000	0.27	218,497	10,151,142	362,541	10,151,142	362,541	10,151,142	362,541					16,525,073	90,217,879
March	31	1,670,000	51,770,000	0.71	574,567	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541					18,628,276	108,846,154
April	30	1,670,000	50,100,000	1.60	1,294,800	17,673,863	589,129	17,673,863	589,129	17,673,863	589,129			2.34	1,892,026	-3,518,814	105,327,341
May	31	1,670,000	51,770,000	1.73	1,400,002	18,262,991	589,129	18,262,991	589,129	9,426,060	589,129	6.7	15,532,526	3.91	3,160,929	-11,475,496	93,851,844
June	30	1,670,000	50,100,000	2.99	2,419,657	17,673,863	589,129	17,673,863	589,129		589,129	13.7	31,688,200	4.22	3,415,843	-17,932,111	75,919,733
July	31	1,670,000	51,770,000	2.41	1,950,292	18,262,991	589,129	18,262,991	589,129		589,129	19.1	44,104,989	5.84	4,724,400	-31,635,080	44,284,653
August	31	1,670,000	51,770,000	1.01	817,342	18,262,991	589,129	18,262,991	589,129		589,129	17.8	41,058,491	5.02	4,061,624	-29,058,755	15,225,898
September	30	1,670,000	50,100,000	3.17	2,565,322	17,673,863	589,129	17,673,863	589,129	8,836,931	589,129	9.2	21,117,774	3.20	2,588,790	-15,225,898	-
October	31	1,670,000	51,770,000	1.57	1,270,522	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541			1.83	1,484,164	17,840,067	17,840,067
November	30	1,670,000	50,100,000	1.64	1,327,169	10,876,223	362,541	10,876,223	362,541	10,876,223	362,541					18,798,500	36,638,567
December	31	1,670,000	51,770,000	1.10	890,175	11,238,764	362,541	11,238,764	362,541	11,238,764	362,541					18,943,883	55,582,450

						% To IP Beds	100%
Land Application area=	117	acres	Lagoon Water Surface Area			% of Agro Rates	72.64%
	5,096,520	sf	Total Treatment	14 acres	609,840 SF		
			Storage	15.8 acres	688,248 SF		
			Total	29.8 acres	1,298,088 SF		

Cumulative Storage is the amount of water in the lagoons at the end of the month
The system does not discharge to IP bed C and the irrigation system simultaneously

Belgrade Wastewater Master Plan
Alternative D-4
Lagoon #2 Seasonal Storage Calculations

Add 4.35 feet to the top

Minimum Operating Depth	0	ft
Side Slope H:1	4	
Minimum Water Length	444	ft
Minimum Water Width	440	ft
Minimum Water Area	195,360	sf
	4.5	acres
Additional Height	4.35	feet
Operating Depth	14.8	ft
Water Surface Length	562.4	ft
Water Surface Depth	558.4	ft
Water Surface Area	314,044	sf
	7.21	acres
Operation Volume		
Average End Method	3,769,591	cf
	28,200,309	gal
	28.2	MG
Conic Approximation Method	3,735,011	cf
	27,941,618	gallons
	27.9	MG
Total Storage Volume	**109.4**	**MG**

ENGLISH
BIG GUN 9/07

the original
BIG GUN® SPRINKLER

NELSON

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NELSON BIG GUN® SPRINKLERS

The Leader in Quality, Performance & Support

In the field of large-volume sprinklers, Nelson Big Guns® are recognized the world over as the leader in quality, performance and technical support. They are engineered and precision manufactured for heavy-duty reliability and long wear life. Every Nelson Big Gun® is subjected to the toughest inspection testing and quality control standards in the industry — including individual water testing of every gun at the factory.

Durable and reliable with engineered simplicity.

The preferred choice for tough applications.

NELSON

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The only gun for hour after hour, year after year operation.

SET IT AND FORGET IT. A simple, positive, reliable adjustment allows for setting the arc to within 1 degree, without overriding the stops. The setting will not change over time, a concept proven with years in the field.

WORKS RIGHT OUT OF THE BOX. Nelson pioneered the concept of a slow, steady and uniform forward and reverse drive action. The drive vane automatically compensates through the full range of nozzle sizes and pressures.

APPLICATIONS

- Pivot End Gun Irrigation
- Traveler Irrigation
- Solid Set Irrigation
  - Corn, Sugar Cane, Pineapple, Pastures, etc.
- Environmental Applications
  - Feedlot Dust Suppression & Cooling
  - Wastewater Applications
  - Mining Dust Suppression
- Sports Field Applications
  - Turf Irrigation
  - Synthetic Turf Cooling & Conditioning

OPTIONS

- Adjustable Trajectory
- 800 Series Valve/Big Gun® Combination
- Nozzle Valve
- Quick Coupling Valve
- Special Coatings
- Add-on Kits: Secondary Nozzle, Wedge and Counterbalance

(See *Big Gun® Add-on Kits* literature for details.)

NOZZLE VALVE

800P END GUN
CONTROL VALVE*

*No electric solenoid required for Big Gun® control when used with a booster pump

HEAVY DUTY — PRECIS

THE BIG GUN® NAME has a world-wide reputation for quality, performance and support in a number of heavy-duty agricultural and industrial applications.

GREATEST RANGE OF OPTIONS. Full & part-circle sprinklers available in a variety of trajectory, nozzle & coating options.

TWIN BALL BEARING IN LOWER BEARING UNIT. Gun has a total of 9 ball bearings — all sealed and lifetime lubricated for long wear life and reliability.

HAND ADJUSTABLE STOPS for Precise Arc Control.

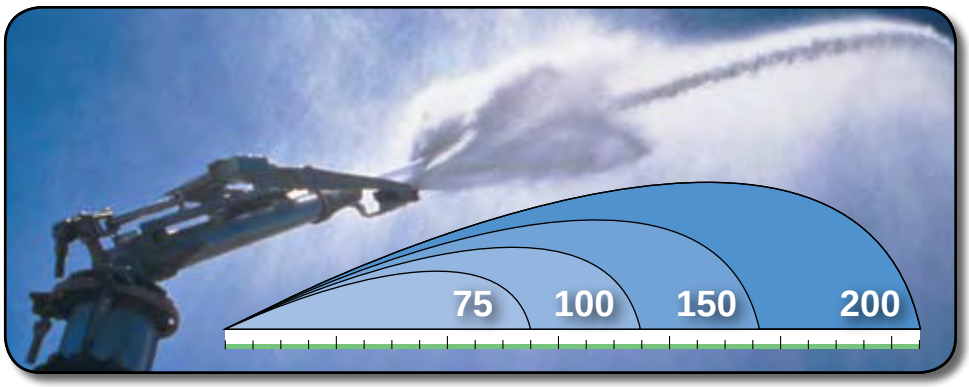
SION MANUFACTURED

EXCELLENT DRIVE ACTION. The SR Series has the same slow forward and reverse speeds, increasing stability and improving uniformity.

PATENTED PRESSURE AND FLOW COMPENSATING DRIVE SPOON eliminates need for adjustments throughout the full range of nozzle sizes and pressures.

CONSISTENT BRAKE LOAD. The brake provides a consistent resistance to rotation over the life of the gun.

BIG GUN® OPTIONS AVAILABLE



TO ORDER BIG GUNS® SPECIFY THE FOLLOWING:

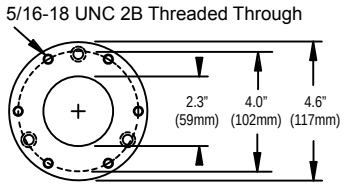
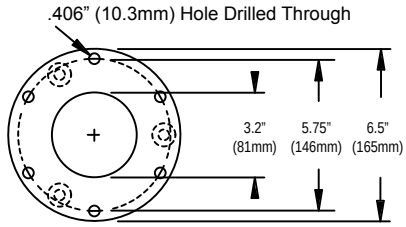
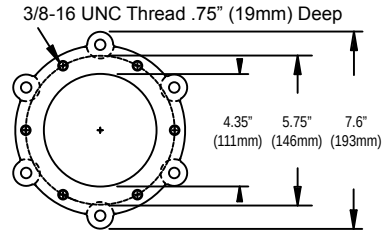
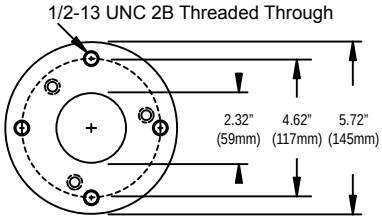
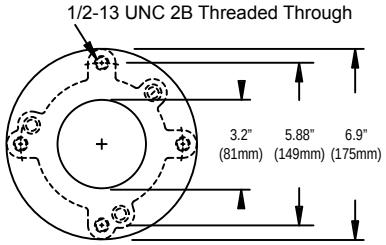
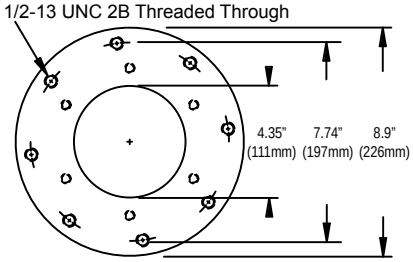
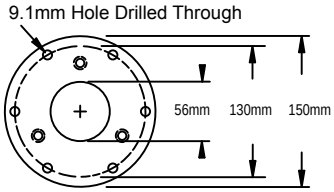
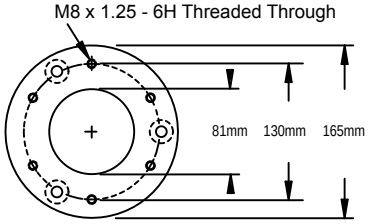
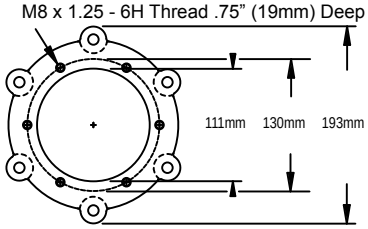
Model No., Trajectory, Connection Size & Type, Nozzle Size & Type, Optional Coatings (Anodized or Anodized and Powder Coated) NOTE: Extended lead time may be necessary for large quantities of anodized or anodized and powder coated products.

Specification Example:
SR100 (24°), 2" FNPT, 100T-0.8"

	75 SERIES		100 SERIES			150 SERIES			200 SERIES	
PERFORMANCE	30-160 GPM (6.8-36.3 M³/H) 25-80 PSI (1.75-6 Kg/cm²)		50-300 GPM (10-70 M³/H) 40-110 PSI (3.5-8 Kg/cm²)			100-630 GPM (23-150 M³/H) 50-120 PSI (3.5-9 Kg/cm²)			250-1200 GPM (55-275 M³/H) 60-130 PSI (4-9 Kg/cm²)	
MODEL & TRAJECTORY	Full Circle F75	Part Circle SR75	Full Circle F100	Part Circle SR100	Part Circle SRA100	Full Circle F150	Part Circle SR150	Part Circle SRA150	Full Circle F200	Part Circle SR200
	21°, 24°	18°, 21°, 24°, 43°	18°, 21°, 24°, 43°		15-45° Adjustable	21°, 24°	21°, 24°, 27°, 43°	15-45° Adjustable	21°, 24°, 27°	
NOZZLE OPTIONS – TAPER (0.4-0.8" (10.2-20.3 mm))	Not Available		0.5-1.0" (12.7-25.4 mm): 100T (Specify Size)			0.7-1.4" (17.8-35.6 mm): 150T (Specify Size)			1.05-1.9" (26.7-48.3 mm): 200T (Specify Size)	
NOZZLE OPTIONS – TAPER RING	TR75 (Specify Size)		100TR (Specify Size)		NA for SRNV	150TR (Specify Size)			Not Available	
NOZZLE OPTIONS – RING	Not Available		100R (Includes Set of Rings)		NA for SRNV	150R (Includes Set of Rings)			200R (Includes Set of Rings)	
SPECIAL OPTIONS	Not Available		Anodized & Powder Coated, Vaneless Range Tube*			Anodized & Powder Coated, Stainless Steel (SRA150 N/A), Vaneless Range Tube			Anodized & Powder Coated	
ADD-ON KITS	HD Lower Bearing, 12° Wedge Kit, Counterbalance Kit, Stream Straightener Vane		Low-Pressure Drive Vane Kit, Counterbalance Kit, Secondary Nozzle Kit, 12° Wedge Kit, Stream Straightener Vane			Counterbalance Kit, Secondary Nozzle Kit, Stream Straightener Vane			Secondary Nozzle Kit (standard), 12° Wedge Kit (SR200 only)	
MOUNTING DETAILS	Fits QC** & 2" 800 Series Valve		Fits QC** & 2" 800 Series Valve (QC NA for SRNV100)			Substantial thrust on riser, use 3" valve minimum			Substantial thrust on riser, use 4" valve minimum	
CONNECTION OPTIONS	1 1/2" or 2" FNPT or FBSP ANSI/DIN Nelson or Euro Flange		2" FNPT or FBSP, 2 1/2" FNPT ANSI/DIN, Nelson or Euro Flange		2" FNPT or FBSP for SRNV	Nelson, Euro or ANSI/DIN Flange Also, Nelson Flange to Female Adapters			Nelson, Euro or ANSI/DIN Flange Also, Nelson Flange to Female Adapters	

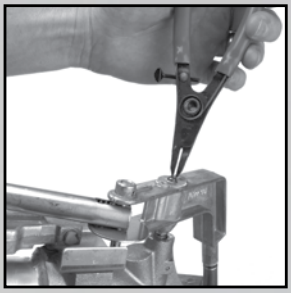
*Vaneless Range Tube option is for wastewater applications containing hair, straw, etc.
** The "Quick Coupling Valve" inlet is available in both 2" and 3" FNPT and FBSP for connection to the piping system. The "Quick Coupling Key" outlet is available in 2" FNPT, 2" FBSP, and Nelson Flange Connection for connection to the Big Gun.

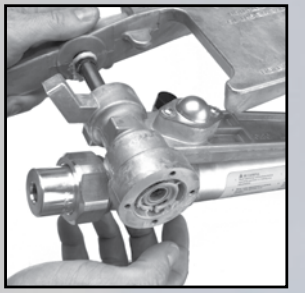
BIG GUN® FLANGE DETAILS

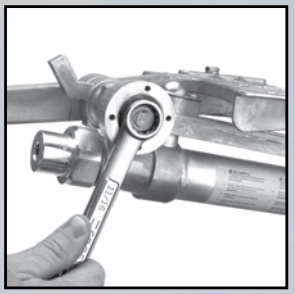
	75 & 100 SERIES	150 SERIES	200 SERIES
NELSON FLANGE	 Use 5/16-18 Bolts *Connects to 2" Nelson Flange Bolt Pattern*	 Use 3/8-16 Bolts & Nuts or M10 Bolts & Nuts *Connects to 3" Nelson Flange Bolt Pattern*	 Use 3/8-16 Bolts & Nuts *Connects to 4" Nelson Flange Bolt Pattern* *(F200 has same bolt pattern as SR150.)*
ANSI/DIN COMPATIBLE FLANGE	 Use 1/2-13 Bolts *Connects to 2" ANSI or 50mm DIN Flanges*	 Use 1/2-13 Bolts *Connects to 3" ANSI or 80mm DIN Flanges*	 Use 1/2-13 Bolts *Connects to 4" ANSI or 100mm DIN Flanges*
EURO FLANGE	 Use M8 Bolts & Nuts *Connects to European Traveler Flange*	 Use M8 x 1.25 Bolts *Connects to European Traveler Flange*	 Use M8 x 1.25 Bolts *Connects to European Traveler Flange*

Contact the factory or go to **www.nelsonirrigation.com** for Parts Lists, Operation & Maintenance Guides, Repair Kits, Dimensional Drawings, Add-on Kit literature & Thrust Force information.

Nelson Big Guns are easy to repair with readily available parts.







BIG GUN® PERFORMANCE (U.S. UNITS)

Flow and diameter (feet) information at various pressures with different nozzle sizes. (See information at bottom of page 11.)

75 TAPER RING NOZZLE — 24° TRAJECTORY

	0.4″		0.45″		0.5″		0.55″		0.6″		0.65″		0.7″		0.75″		0.8″	
PSI	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT
25*	—	—	—	—	—	—	42	146	50	155	59	161	69	167	80	174	91	182
30*	—	—	—	—	37	158	45	158	55	165	64	172	75	182	87	187	99	192
35	—	—	32	154	40	164	49	172	59	178	69	191	81	196	93	202	106	208
40	27	149	35	160	43	171	52	180	63	190	74	198	87	204	98	213	112	221
45	29	155	37	167	46	180	56	189	67	198	79	206	91	214	104	223	118	230
50	30	161	39	174	48	186	59	195	70	203	83	212	95	220	109	230	123	237
55	32	165	41	179	50	193	62	203	74	213	87	221	100	230	115	239	130	247
60	33	169	42	184	53	198	64	208	77	220	91	228	104	237	120	245	136	254
65	35	172	44	189	55	205	67	216	80	227	95	237	109	247	125	254	142	263
70	36	175	45	194	57	210	69	221	83	232	98	243	113	254	129	260	147	270
75	37	179	47	201	59	217	72	228	86	239	101	250	117	261	134	268	153	277
80	39	182	49	207	61	222	74	234	89	244	105	256	121	266	138	274	158	283

*Operating at pressures above 30 PSI provides better performance.

100 TAPER BORE NOZZLE — 24° TRAJECTORY

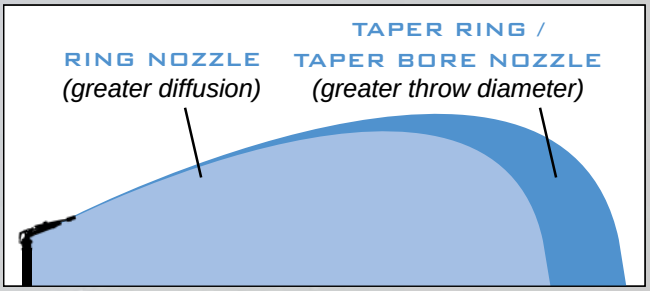
	0.5″		0.55″		0.6″		0.65″		0.7″		0.75″		0.8″		0.85″		0.9″		1.0″	
PSI	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT
40	47	191	57	202	66	213	78	222	91	230	103	240	118	250	134	256	152	262	—	—
50	50	205	64	215	74	225	87	235	100	245	115	256	130	265	150	273	165	280	204	300
60	55	215	69	227	81	240	96	250	110	260	126	270	143	280	164	288	182	295	224	316
70	60	225	75	238	88	250	103	263	120	275	136	283	155	295	177	302	197	310	243	338
80	64	235	79	248	94	260	110	273	128	285	146	295	165	305	189	314	210	325	258	354
90	68	245	83	258	100	270	117	283	135	295	155	306	175	315	201	326	223	335	274	362
100	72	255	87	268	106	280	123	293	143	305	163	316	185	325	212	336	235	345	289	372
110	76	265	92	278	111	290	129	303	150	315	171	324	195	335	222	344	247	355	304	380

150 TAPER BORE NOZZLE — 24° TRAJECTORY

	0.7″		0.8″		0.9″		1.0″		1.1″		1.2″		1.3″		1.4″	
PSI	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT
50	100	250	130	270	165	290	205	310	255	330	300	345	350	360	408	373
60	110	265	143	285	182	305	225	325	275	345	330	365	385	380	446	396
70	120	280	155	300	197	320	245	340	295	360	355	380	415	395	483	412
80	128	290	165	310	210	335	260	355	315	375	380	395	445	410	516	427
90	135	300	175	320	223	345	275	365	335	390	405	410	475	425	547	442
100	143	310	185	330	235	355	290	375	355	400	425	420	500	440	577	458
110	150	320	195	340	247	365	305	385	370	410	445	430	525	450	605	471
120	157	330	204	350	258	375	320	395	385	420	465	440	545	460	632	481

200 TAPER BORE NOZZLE — 27° TRAJECTORY

	1.05″		1.1″		1.2″		1.3″		1.4″		1.5″		1.6″		1.75″		1.9″	
PSI	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT	GPM	DIAM. FT
60	250	345	285	355	330	375	385	390	445	410	515	430	585	445	695	470	825	495
70	270	360	310	380	355	395	415	410	480	430	555	450	630	465	755	495	890	515
80	290	375	330	395	380	410	445	430	515	450	590	470	675	485	805	515	950	535
90	310	390	350	410	405	425	475	445	545	465	625	485	715	505	855	535	1005	555
100	325	400	370	420	425	440	500	460	575	480	660	500	755	520	900	550	1060	575
110	340	410	390	430	445	450	525	470	605	495	695	515	790	535	945	565	1110	590
120	355	420	405	440	465	460	545	480	630	505	725	530	825	550	985	580	1160	605
130	370	425	425	445	485	465	565	485	655	515	755	540	860	560	1025	590	1210	620



See opposite page for nozzle descriptions.

BIG GUN® PERFORMANCE (METRIC)

Flow and diameter (meters) information at various pressures with different nozzle sizes. (See information at bottom of page.)

75 TAPER RING NOZZLE TR75 — 24° TRAJECTORY

	10.2 mm			11.4 mm			12.7 mm			14.0 mm			15.2 mm			16.5 mm			17.8 mm			19.1 mm			20.3 mm		
Kg/cm²	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M
1.75*	—	—	—	—	—	—	—	—	—	2.64	9.5	44	3.17	11.4	48	3.72	13.4	49	4.30	15.5	51	4.91	17.7	54	5.59	20.1	56
2.00*	—	—	—	—	—	—	2.33	8.4	48	2.82	10.2	48	3.39	12.2	51	3.98	14.3	52	4.59	16.5	56	5.25	18.9	58	5.97	21.5	59
2.50	—	—	—	2.11	7.6	47	2.61	9.4	50	3.16	11.4	53	3.79	13.6	55	4.45	16.0	58	5.14	18.5	60	5.87	21.1	62	6.68	24.0	64
3.00	1.83	6.6	47	2.32	8.3	50	2.86	10.3	53	3.46	12.4	57	4.15	14.9	59	4.88	17.6	61	5.63	20.3	63	6.43	23.1	66	7.32	26.3	69
3.50	1.98	7.1	49	2.50	9.0	52	3.09	11.1	57	3.74	13.4	60	4.48	16.1	62	5.27	19.0	64	6.08	21.9	67	6.95	25.0	70	7.90	28.4	73
4.00	2.11	7.6	50	2.67	9.6	54	3.30	11.9	59	3.99	14.4	62	4.79	17.2	65	5.63	20.3	67	6.50	23.4	71	7.43	26.7	73	8.45	30.4	76
4.50	2.24	8.1	52	2.84	10.2	57	3.50	12.6	62	4.24	15.2	66	5.08	18.3	68	5.97	21.5	71	6.89	24.8	75	7.88	28.4	78	8.96	32.3	80
5.00	2.36	8.5	53	2.99	10.8	60	3.69	13.3	64	4.46	16.1	68	5.35	19.3	70	6.30	22.7	74	7.26	26.1	78	8.30	29.9	80	9.45	34.0	84
5.50	2.48	8.9	55	3.13	11.3	62	3.87	13.9	66	4.68	16.9	70	5.61	20.2	73	6.60	23.8	77	7.62	27.4	81	8.71	31.3	83	9.90	35.7	86
6.00	2.59	9.3	56	3.27	11.8	63	4.04	14.6	68	4.89	17.6	72	5.86	21.1	74	6.90	24.8	79	7.96	28.6	84	9.09	32.7	85	10.3	37.2	87

*Operating at pressures above 2 Kg/cm² provides better performance.

100 TAPER BORE NOZZLE — 24° TRAJECTORY

	12.7 mm			14.0 mm			15.2 mm			16.5 mm			17.8 mm			19.1mm			20.3 mm			21.6 mm			22.9 mm			25.4 mm		
Kg/cm²	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M
3.0	3.00	10.8	59.5	3.73	13.4	62.6	4.33	15.6	66.1	5.09	18.3	66.8	5.84	21.0	71.4	6.71	24.1	74.5	7.64	27.5	77.5	8.74	31.5	79.5	9.67	34.8	81.4	11.9	42.8	88.1
4.0	3.40	12.2	64.3	4.25	15.3	67.8	5.00	18.0	71.8	5.86	21.1	74.8	6.82	24.6	77.8	7.73	27.8	81.0	8.66	31.2	82.8	10.1	36.2	86.4	11.2	40.4	88.6	13.8	49.5	94.8
5.0	3.79	13.6	69.0	4.72	17.0	72.7	5.59	20.1	76.4	6.56	23.6	80.2	7.62	27.5	84.4	8.66	31.2	86.7	9.91	34.9	90.4	11.3	40.5	92.5	12.5	45.2	94.7	15.5	55.6	103
6.0	4.17	15.0	73.4	5.14	18.5	77.3	6.12	22.1	80.7	7.19	25.9	85.0	8.35	30.1	88.7	9.51	34.3	91.8	10.9	38.2	94.7	12.4	44.5	97.7	13.7	49.5	101	16.8	60.5	109
7.0	4.53	16.3	77.6	5.52	19.9	81.6	6.61	23.8	85.0	7.75	27.9	89.3	9.02	32.5	93.0	10.3	37.0	96.1	11.7	41.3	99.0	13.3	48.0	102.2	14.8	53.5	105	18.2	65.5	113
8.0	4.89	17.6	81.7	5.84	21.0	85.7	7.07	25.5	89.3	8.25	29.7	93.1	9.64	34.8	97.3	11.0	39.4	99.7	12.5	44.1	103	14.2	51.2	105.8	15.9	57.2	109	19.5	70.2	116

150 TAPER BORE NOZZLE — 24° TRAJECTORY

	17.8 mm			20.3 mm			22.9 mm			25.4 mm			27.9 mm			30.5 mm			33.0 mm			35.6 mm		
Kg/cm²	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M
3.5	6.39	23.0	76.0	8.29	29.8	82.0	10.5	37.8	88.0	13.0	46.9	95.0	15.9	57.1	101	19.0	68.3	105	22.3	80.1	110	25.8	92.9	114
4.0	6.83	24.6	79.6	8.86	31.9	85.6	11.2	40.4	91.6	13.9	50.1	97.8	16.9	61.0	104	20.3	73.0	109	23.8	85.7	114	27.4	98.6	118
5.0	7.63	27.5	85.4	9.91	35.7	91.6	12.6	45.2	98.6	15.6	56.0	105	18.9	68.2	111	22.7	81.7	117	26.6	95.8	121	30.8	111	126
6.0	8.36	30.1	89.7	10.9	39.1	96.7	13.8	49.5	104	17.0	61.3	110	20.8	74.7	117	24.9	89.5	123	29.1	105	128	33.6	121	133
7.0	9.03	32.5	95.0	11.7	42.2	101	14.9	53.5	108	18.4	66.3	114	22.4	80.7	122	26.8	96.6	128	31.5	113	134	36.4	131	139
8.0	9.66	34.8	99.3	12.5	45.1	105	15.9	57.2	112	19.7	70.8	118	24.0	86.3	126	28.7	103	132	33.7	121	138	38.9	140	145
9.0	10.2	36.9	104	13.3	47.9	110	16.8	60.6	117	20.9	75.1	123	25.4	91.5	131	30.4	110	137	35.7	129	143	41.1	148	149

200 TAPER BORE NOZZLE — 27° TRAJECTORY

	26.7 mm			27.9 mm			30.5 mm			33.0 mm			35.6 mm			38.1 mm			40.6 mm			44.5 mm			48.3 mm		
Kg/cm²	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M	L/S	M³/H	DIAM. M
4.0	15.5	55.7	104	17.8	63.9	106	20.3	73.1	112	23.8	85.8	117	27.5	98.9	123	32.2	116	129	36.1	130	134	42.9	154	141	50.7	183	149
5.0	17.3	62.3	111	19.9	71.5	117	22.7	81.7	121	26.7	96.0	126	30.7	111	132	36.0	130	138	40.3	145	143	48.0	173	152	56.7	204	158
6.0	19.0	68.2	115	21.8	78.3	121	24.9	89.5	126	29.2	105	132	33.7	121	138	39.4	142	144	44.2	159	149	52.6	189	158	62.1	224	164
7.0	20.5	73.7	122	23.5	84.6	128	26.9	96.7	134	31.5	114	140	36.3	131	146	42.6	153	152	47.7	172	159	56.8	204	168	67.1	241	175
8.0	21.9	78.8	126	25.1	90.4	132	28.7	103	138	33.7	121	144	38.9	140	152	45.5	164	159	51.0	184	165	60.7	218	174	71.7	258	182
9.0	23.2	83.6	130	26.6	95.9	136	30.4	110	142	35.8	129	148	41.2	148	157	48.3	174	164	54.1	195	170	64.4	232	180	76.0	274	188

Diameters are based on a 24° trajectory for the 75, 100 and 150 Series and a 27° trajectory for the 200 Series. The lower trajectory angles result in better wind fighting ability, but reduced throw distances. Throw reduction depends upon nozzle flow rate. In general, the throw distance is reduced approximately 3% with each 3° drop in trajectory angle. Use of the wedge insert to modify trajectory will affect distance. Big Gun® performance data has been obtained under ideal test conditions and may be adversely affected by wind, poor hydraulic entrance conditions or other factors. Test riser height of 3 feet (0.91 meters) above measurement surface. No representation regarding droplet condition, uniformity, application rate, or suitability for a particular application is made herein.

Additional nozzle options and sizes available. Go to www.nelsonirrigation.com or contact the factory for nozzle performance.

TAPER BORE NOZZLE. Most common nozzle type. Used where the available water flow and pressure are consistent. A nozzle size must be specified when ordering a Big Gun with a Taper Bore Nozzle. *The Nozzle Valve End Gun requires a Taper Bore Nozzle.*

RING NOZZLE SET. The Ring Nozzle Set is an easy and economic way of changing nozzles to match the available water flow and pressure. These are commonly used where the available water flow and pressure are variable and or when the Big Gun is shifted between various water sources with different capacities. The abrupt orifice of the nozzle is less efficient so the radius of throw is less than that achieved with an equivalent diameter Taper Bore nozzle. The abrupt orifice of the Ring Nozzle does break the stream of water up more, which can be an advantage in low pressure applications. The Ring Nozzle comes with a set of rings. *The Ring Nozzle should not be used with the Nozzle Valve End Gun.*

TAPER RING NOZZLE. This nozzle combines the changeability of a Ring Nozzle with some of the efficiency of a Taper Bore Nozzle. When ordering the Taper Ring Nozzle, specify the size as only one Taper Ring comes with the nozzle body and cap. Additional taper ring sizes can be purchased. *The Taper Ring Nozzle should not be used with the Nozzle Valve End Gun.*

THE BEST PRODUCT SUPPORT IN THE INDUSTRY. Nelson is proud of its reputation for quality and integrity. We work hard to make our products the best, and we stand behind them with a one-year warranty.

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Tel: 509.525.7660 Fax: 509.525.7907 info@nelsonirrigation.com

Nelson Irrigation Corporation of Australia 35 Sudbury Street, Darra QLD 4074
Tel: +61 7 3715 8555 Fax: +61 7 3715 8666 info@nelsonirrigation.com.au

WARRANTY AND DISCLAIMER: Nelson Big Gun® Sprinklers are warranted for one year from date of original sale to be free of defective materials and workmanship when used within the working specifications for which the products were designed and under normal use and service. The manufacturer assumes no responsibility for installation, removal or unauthorized repair of defective parts. The manufacturer's liability under this warranty is limited solely to replacement or repair of defective parts and the manufacturer will not be liable for any crop or other consequential damages resulting from defects or breach of warranty. THIS WARRANTy IS EXPRESSLy IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTABILITy AND FITNESS FOR PARTICULAR PURPOSES AND OF ALL OTHER OBLIGATIONS OR LIABILITIES OF MANUFACTURER. No agent, employee or representative of the manufacturer has authority to waive, alter or add to the provisions of this warranty, nor to make any representations or warranty not contained herein.

This product may be covered by one or more of the following U.S. Patent Nos. D297,453, 3,559,887, 3,744,720, 4,193,548, 4,669,663 and other U.S. Patents pending or corresponding issued or pending foreign patents.

Belgrade Wastewater Master Plan
Alternative D-4
Utility Cost Estimates

Irrigation Area 117 acres
5,096,520 SF

Month	Rate	Rate	Rate	Pump run times
	Inches	Gallons	gpd	hr/day
May	6.73	21,382,930	1,425,529	13.2
June	13.73	43,623,718	1,454,124	13.5
July	19.11	60,717,353	1,958,624	18.1
August	17.76	56,428,058	1,820,260	16.9
September	9.15	29,071,888	1,938,126	17.9
October	0.00	0	0	0.0
Annual	66.48	211,223,946	1,731,344	16.0

Assumed pump size 1800 gpm

number of sprinklers used at a time: 6 sprinklers The city has 52 sprinkler heads total

flow rate per sprinkler 300 gpm

Goal sprinkler radius 200 feet

According to Nelson Irrigation, the original Big Gun sheet

between 69 and 75 gpm for an application radius of 191 to 213 feet requires 35 to 55 psi at the sprinkler heads

Assuming a 40 HP motor
Motor Horse Power= 40 HP
29828 W
29.828 kW

	Run Times	Daily energy Requirements	Monthly energy Requiremen	Monthly Utility Cost
	hr/day	kW-hr	kW-hr	
May	13.1993392	393.7098911	5905.648366	$591
June	13.4641105	401.6074892	12048.22468	$1,205
July	18.13541	540.9430105	16769.23333	$1,677
August	16.8542586	502.7288261	15584.59361	$1,558
September	17.9456098	535.2816499	8029.224748	$803
			Annual Utility Cost	**$5,834**

APPENDIX 7B

Wastewater Operation and Maintenance Tasks and Manpower

The purpose of this memorandum is to present a summary of operation and maintenance (O&M) tasks for the City's wastewater collection and treatment systems. In addition, some personnel and manpower estimates have been provided by other municipalities and in the 2004 *Operations and Maintenance Manual* for the wastewater treatment plant (WWTP). This memorandum does not provide a comprehensive analysis of the wastewater system manpower demands; rather it is intended to provide information the City can reference in conjunction with their practical experience to estimate personnel requirements.

Recommendations for the normal operation and maintenance of the City's lift stations, lagoons, I/P beds, and irrigation system can be found in the operation and maintenance manuals for each installation and from manufacturers' literature. TD&H has performed additional research into the typical maintenance procedures the City should consider when evaluating their staffing requirements. Several municipalities were contacted for information regarding their staffing and maintenance procedures; the City of Great Falls and the City of Livingston responded.

EPA Recommendations

A standard EPA Plant Checklist was provided in the 2004 WWTP O&M Manual. The checklist was taken from the 1997 EPA report *Operations Manual Stabilization Ponds.* An updated version of this checklist is available from the EPA's 2011 report *Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers.* The checklist has been reproduced in this memorandum. It provides a list of typical components associated with a lagoon treatment system and the recommended frequency of various maintenance tasks. The checklist is intended to be generic, therefore various activities are not applicable to the City of Belgrade.

EPA Example Pond System Checklist							
Operation and Maintenance	**Frequency**						
	Daily	**Weekly**	**Monthly**	**3 Months**	**6 Months**	**Yearly**	**As Needed**
Plant Survey							
Drive around the pond taking note of the following conditions:							
Any buildup of scum on pond surface and discharge outlet boxes		x					
Signs of burrowing animals	x						
Anaerobic conditions: noted by odor and black color, floating sludge, large number of gas bubbles	x						
Water-grown weeds	x						
Evidence of dike erosion	x						
Fence damage	x						
Ice buildup in winter						x	x
Evidence of short-circuiting	x						
A review of the information obtained from the observations should be included in the next year's planning activities.							

Plan, schedule, and correct problems found. Use troubleshooting section of this manual for information.						x	
Pretreatment							
Clean inlet and screens, and properly dispose of trash.	x						
Check inlet flow meter and float well.	x						
If discharge is once or twice per year, the discharge permit may require observations of the following:							
Odor		x					
Aquatic plant coverage of pond		x					
Pond depth		x					
Dike condition		x					
Ice cover		x					
Flow (influent)	x						
Rainfall (or snowfall)	x						
Note: Each state has requirements for data collected prior to and during discharge that are defined in the pond system discharge permit.							
If discharge is continuous, the discharge permit may require the following information:							
Weather	x						
Flow	x						
Condition of all cells	x						
Depth of all cells	x						
EPA Example Pond System Checklist							
Operation and Maintenance	**Frequency**						
	Daily	**Weekly**	**Monthly**	**3 Months**	**6 Months**	**Yearly**	**As Needed**
Pretreatment (continued)							
Pond effluent:	x						
DO and pH grab sample	x						
Cr residual	x						
BOD5 and TSS run on compositied sampled							x
Microbial tests							x
kg (lb) of Cr used and remaining	x						
Other tests and frequency information will be defined in the individual permit.							
Mechanical Equipment							
Check mechanical equipment and perform scheduled preventative maintenance on the following pieces of equipment according to the manufacturer's recommendations.							
Pump Stations:							
Remove debris	x						

Check pump operation	x						
Run emergency generator		x					
Log running times	x						
Clean floats, bubblers, or other control devices		x					
Lubricate							x
Communicating devices:							
Check cutters		x					
Lubricate							x
Aerators:							
Log running times	x						
Check amperage		x					
Chlorinators:							
Check feed rate	x						
Change cylinders							x
Flow measuring devices:							
Check and clean floats, etc.	x						
Verify accuracy		x					
Valves and gates:							
Check to see if set correctly	x						
Open and close to be sure they are operational		x					

Wastewater Collection System

Belgrade's wastewater collection system includes gravity mains, manholes, six lift stations, and pressurized force mains to collect wastewater and transport it to the wastewater treatment plant. In addition to the example tasks provided in the above table, the City of Great Falls provided a description of their lift station and collection system O&M practices.

The City of Great Falls' lift station maintenance personnel indicate they adhere to all manufacturer recommendations during the warranty period before settling into their normal O&M schedule for submersible lift stations. Included in their typical tasks are:

- Daily
    - Check SCADA trends for changes in performance or inflow
    - Check number of pump starts and stops
- Monthly
    - Perform a Lift Station Condition Review which includes:
        - Test the UPS (uninterruptible power supply)
        - Check high level alarm by temporarily disabling pump start
- Semi-Annually
    - Volt and amp check

In addition to the lift station recommendations from the City of Great Falls, it is also considered a best practice to exercise lift station valves annually, at a minimum.

The City of Great Falls also provided routine maintenance activities associated with their gravity mains and manholes. The City jet rods all of the mains every two years in accordance with their municipal insurance policy. While the crews work on the mains, they also log the condition of each manhole. The City is also in the process of performing a TV inspection of the entire system; however, they suspect that process will take several years given the expense and required effort.

The City of Livingston did not provide information with regards to their collection system O&M; however, they do require 1.5 persons to maintain the collection system.

Wastewater Treatment System

Belgrade's wastewater treatment plant includes blowers, aerated ponds, infiltration/percolation (I/P) beds, spray irrigation, pumps, piping, and control structures. Belgrade is unique; similarly-sized cities and towns have mechanical treatment plants. For example, the cities of Livingston and Miles City, whose populations are similar to Belgrade's, operate mechanical plants. The operating and maintenance effort is not equivalent for mechanical and lagoon treatment plants. Livingston wastewater personnel indicate their mechanical plant requires 3.5 full time operators; there is also a foreman/superintendent that manages the water and sewer staff.

The typical tasks required for the operation and maintenance of a lagoon wastewater treatment plant are provided in the above EPA table. In addition, Volume I of the 2004 *Operations and Maintenance Manual* highlighted several recommended tasks:

- Monitor DO (dissolved oxygen) levels frequently and adjust aeration rates if odor is an issue;

- Regularly check the blower surge control amperage meter and adjust so blowers operate near their design point,
- All valving equipment should be inspected and cleaned, when necessary, on a monthly basis;
- Inspect the Pond 3 riprap periodically and particularly following periods of high wind as well as after spring ice thaw;
- Grass around the ponds, I/P beds, and buildings should be mowed regularly to prevent excessive growth which would attract waterfowl;
- Waterfowl control around the I/P beds – check for nests and discourage waterfowl with noise control or hunting dogs;
- Water quality sampling and monitoring according to the permit requirements;
- Housekeeping of the grounds and buildings at the treatment plant – snow removal, lawn care, painting, building maintenance, tool maintenance, general upkeep;
- Equipment lubrication in accordance with manufacturer recommendations.

Volume I of the Belgrade treatment plant's 2004 *Operations and Maintenance Manual* presents an estimate of man-hours required for typical O&M. The manual recommends two personnel are needed: an operator and assistant operator. The operator is expected to provide 1,520 man-hours and the assistant operator to provide 166 man-hours to manage the treatment plant, I/P beds, and irrigation system on an annual basis. If the projected man-hours are spread evenly over 52 weeks in a year, the result is that an operator is required for approximately 30 hours per week and an assistant operator for 3-4 hours per week. Considering the wastewater treatment plant has operated for over ten years, the estimated manpower from the 2004 manual may not reflect the reality at the plant.

Personnel vs. Population

A simplified method of evaluating the personnel requirements of the Belgrade wastewater system is to compare the number of employees to the population served by the utility. For example, the City of Livingston utilizes 5 personnel, plus a superintendent, for the wastewater collection and treatment systems. Livingston's population is approximately 7,400 persons. A water and sewer authority on the east coast serves a population of 180,000 persons with a staff of 178If Belgrade's population is about 8,300 persons, then the proportionate number of staff ranges from 7 to 9 persons.

The City of Great Falls Wastewater Treatment Plant has 14 people on staff; that facility serves a population of approximately 59,000 persons, so the equivalent number of staff for Belgrade would be about 2. Great Falls' public works staff maintains the water, sewer, and storm drain systems, so they don't have a crew dedicated to wastewater collection system maintenance.

Conclusion

Each component in the City's wastewater collection and treatment system requires ongoing maintenance, repairs, record-keeping, and monitoring. We recommend that the City consider the O&M tasks presented in this memorandum during any personnel or workload evaluations.