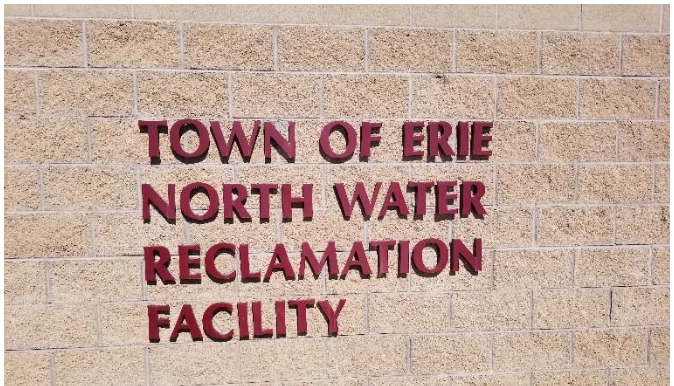


Town of Erie North Water Reclamation Facility Expansion Master Plan

Erie, Colorado

March 19, 2019

March 28, 2019

Ms. Wendi Palmer, P.E. CMF
Civil Engineer
Planning and Development Department
645 Holbrook Street
PO Box 750
Erie, CO 80516

Re: Master Plan Summary - Town of Erie North Water Reclamation Facility

Dear Wendi,

The Town of Erie's North Water Reclamation Facility (NWRF) is permitted to process 1.95 million gallons per day (MGD) of wastewater, and discharges to either Erie's Reuse Reservoirs for reclaimed water and augmentation or Boulder Creek for standard effluent discharge. The plant utilizes an Integrated Fixed-Film Activated Sludge (IFAS) technology for liquids stream treatment, and a lime/pasteurization stabilization process for the solids stream. The facility was originally constructed in 2011, and was upgraded with a series of improvements in 2017.

Due to increasing flows and loads over the past several years the NWRF is reaching its treatment capacity. Erie's population growth has exceeded the rates initially predicted in previous wastewater plans and studies conducted for the NWRF. As a result, the plant is now in need of an expansion to improve overall treatment and increase hydraulic capacity to accommodate growth for the next 10 to 20 years. Additionally, the NWRF experiences issues with the biosolids stabilization process. It is not performing as originally designed and has several operational and maintenance (O&M) issues. The process does not meet Class A regulatory requirements as designed and is at capacity. Therefore, the NWRF must either undergo substantial improvements to render the existing lime/pasteurization facility fully functional, or replace the biosolids stabilization process entirely with a reliable system.

The purpose of this Expansion Plan is to summarize anticipated growth and capacity needs for the NWRF, to develop a set of recommendations, and provide construction cost estimates for those recommendations. The Plan includes several components; the first is a capacity evaluation for both the plant's liquids and solids stream infrastructure. Each unit process was evaluated against growth projections, and a set of expansion requirements were developed from that analysis. This task resulted in recommending a third IFAS liquid treatment train, a second grit handling system, and associated liquids stream pumping and equipment improvements.

The second component of the Plan is a long-term biosolids stabilization study to determine the most viable and sustainable solution for solids treatment at the NWRF. A number of stabilization alternatives were assessed including options for improving the existing system or replacing the process with a new system. After undergoing a preliminary screening to eliminate the impracticable alternatives, the remaining alternatives were evaluated via both a monetary and non-monetary assessment. As a result, the long-term biosolids stabilization recommendation it to implement a new process using Autothermal Thermophilic Aerobic Digestion (ATAD). The ATAD process produces a reliable Class A biosolids product, eliminates chemical use, reduces solids production, reduces or eliminates hauling costs, and is expandable for future growth.

The third component of this Expansion Plan is a set of miscellaneous facility improvement recommendations. These improvements are intended to increase the overall functionality of the plant and to enhance the working environment for NWRF staff.

Lastly, a complete set of recommendations and improvements were incorporated into a Capital Improvements Plan (CIP), which provides a roadmap for implementing future improvements to reliably treat and process wastewater flows for the next 20 years. With this Plan, the NWRF will be more prepared to effectively address impending changes including population growth and regulatory requirements.

If you have any questions regarding the Plan, please contact me at your convenience.

Sincerely,

Adam Parmenter

Adam Parmenter, PE
Professional Associate
W/WW Project Manager
HDR
1670 Broadway, Suite 3400
Denver, CO 80202
D 303.764.1590 **M** 612.501.2010
Adam.Parmenter@hdrinc.com

Contents

Abbreviations………………………………………………………………………………….…………vi-vii
1 Executive Summary 1-1
1.1 Introduction 1-1
1.1.1 Existing Liquids Stream Process Description 1-1
1.1.2 Existing Solids Treatment Process Description 1-2
1.2 Basis of Planning 1-5
1.2.1 Summary of Previous Planning Studies 1-5
1.2.2 Basis of Alternatives Evaluation 1-5
1.2.3 Cost Estimating Methodology 1-6
1.3 Wastewater Characterization 1-6
1.3.1 Population Projections 1-6
1.3.2 Recommended Flows and Loads 1-7
1.4 Regulatory Drivers 1-8
1.5 Liquids Stream Process Performance Evaluation and Alternatives Analysis 1-13
1.5.1 Hydraulic Analysis 1-13
1.5.2 Liquids Stream Process Capacity and Condition Analysis 1-13
1.6 Solids Stream Process Performance Evaluation and Alternatives Analysis 1-15
1.6.1 Existing Solids System Evaluation 1-15
1.6.2 Long-Term Biosolids Stabilization Study 1-16
1.7 Existing Facility Site Improvements 1-18
1.8 Monetary and Non-Monetary Evaluation 1-19
1.8.1 Liquids Stream Monetary Evaluation 1-19
1.8.2 Solids Stream Monetary Evaluation 1-20
1.8.3 Existing Facility Site Improvements Monetary Evaluation 1-21
1.8.4 Summary of Recommended Project Costs 1-22
1.8.5 Non-Monetary Evaluation 1-23
1.9 System Recommendations and Capital Improvements Plan (CIP) 1-24
2 Basis of Planning 2-1
2.1 Introduction 2-1
2.2 Summary of Previous Planning Studies 2-1
2.2.1 Town of Erie 2013 Wastewater Utility Plan 2-1
2.2.2 Town of Erie 2014 Project Implementation Report 2-4
2.2.3 Town of Erie 2015 Wastewater Utility Plan Update 2-5
2.2.4 Preliminary Comparison of Erie Population and Flow Projections 2-7
2.3 Basis for Master Plan Guiding Principles 2-8
2.4 Basis of Alternatives Evaluation 2-11
2.4.1 Evaluation Methodology 2-11

2.4.2 Evaluation Criteria 2-12
2.5 Cost Estimating Methodology 2-14
2.5.1 Capital Costs 2-15
2.5.2 Inflation and Discount Rate 2-16
2.5.3 Operating Costs..........2-16
3 Wastewater Characterization..........3-1
3.1 Introduction 3-1
3.2 Land Use and Wastewater Service Area 3-1
3.3 Population Projections 3-3
3.3.1 Population Growth Comparison..........3-5
3.3.2 Recommended Population Growth Rate 3-6
3.3.3 Build-out Population Expansion..........3-7
3.4 Analysis of Historical Liquids Stream Flows and Loads..........3-8
3.4.1 Per Capita Wastewater Generation and Loading Rates..........3-9
3.5 Projected Liquids Stream Flows and Loads..........3-10
3.6 Analysis of Historical Solids Stream Flows 3-11
3.6.1 Yield Values for Produced Biosolids..........3-11
3.7 Projected Solids Stream Flows 3-12
3.7.1 Solids Stream Projections with Secondary Treatment Expansions..........3-13
3.8 Previous Planning Studies Comparison..........3-14
3.9 Recommended Liquids and Solids Projections Summary 3-16
4 Regulatory Drivers 4-1
4.1 Introduction 4-1
4.2 Water Quality Drivers..........4-1
4.2.1 Current Permit 4-1
4.2.2 Anticipated Future Permit Limits..........4-2
4.2.3 Summary of Anticipated Effluent Limits..........4-7
4.3 Biosolids Drivers 4-7
4.3.1 Metals Criteria 4-8
4.3.2 Pathogen Criteria..........4-10
4.3.3 Class B Biosolids..........4-10
4.3.4 Class A Biosolids..........4-11
4.3.5 Vector Attraction Reduction..........4-12
4.3.6 State of Colorado Biosolids Regulations 4-13
4.3.7 Potential Changes to EPA Part 503 Biosolids Criteria 4-13
4.3.8 Technology Trend Considerations..........4-17
4.3.9 Summary of Biosolids Drivers 4-18
4.4 Other Permitting Drivers..........4-18
4.4.1 Stormwater Management 4-18
4.4.2 Air Permitting..........4-19

4.4.3 Regulatory Agency Coordination....4-19
4.5 Summary of Regulatory Drivers....4-20
5 Liquid Stream Process Performance Evaluation and Alternatives Analysis....5-1
5.1 Introduction....5-1
5.2 Objectives and Purpose....5-2
5.3 Summary of Drivers....5-3
5.4 Summary of Design Year Flows and Loads....5-4
5.5 Hydraulic Analysis....5-5
5.5.1 Deviations from Existing Hydraulic Profile....5-6
5.5.2 Future Build-Out....5-7
5.5.3 Process Scenario Configurations....5-7
5.5.4 Scenario 1 – Three IFAS Trains and Two Secondary Clarifiers....5-8
5.5.5 Scenario 2 – Two IFAS Trains and Two Secondary Clarifiers....5-8
5.5.6 Scenario 3 – Three IFAS Trains and One Secondary Clarifier....5-10
5.5.7 Scenario 4 – Two IFAS Trains and One Secondary Clarifier....5-11
5.5.8 Scenario 5 – 2038 Build-Out....5-12
5.5.9 Summary....5-13
5.6 Liquids Stream Process Capacity and Condition Analysis....5-14
5.6.1 Existing Facility Description....5-14
5.6.2 Headworks....5-19
5.6.3 Influent Pumping....5-20
5.6.4 Grit Handling System....5-21
5.6.5 Integrated Fixed Film Activated Sludge (IFAS) Process....5-25
5.6.6 Blowers....5-32
5.6.7 Clarifiers....5-33
5.6.8 Disc Filter....5-34
5.6.9 UV System....5-36
5.6.10 Summary of Existing Liquids System Evaluation....5-37
5.7 Cost Evaluation of Alternatives....5-41
5.8 Non-Economic Evaluation of Alternatives....5-42
5.9 Summary of Liquids Stream Recommendations....5-42
6 Solids Stream Process Performance Evaluation and Alternatives Analysis....6-1
6.1 Introduction....6-1
6.2 Objectives and Purpose....6-1
6.2.1 Existing Solids System Evaluation:....6-1
6.2.2 Long-Term Biosolids Stabilization Study:....6-1
6.3 Existing Solids System Evaluation....6-2
6.3.1 Existing System Description....6-2
6.3.2 Summary of Design Year Solids Flows....6-7
6.3.3 Solids System Capacity and Condition Analyses....6-9

6.3.4 Existing Lime System 6-9
6.3.5 Existing Solids Pumping 6-11
6.3.6 Existing Solids Storage....................6-14
6.3.7 Existing WAS Thickening 6-16
6.3.8 Existing Dewatering/Stabilization System 6-17
6.3.9 Existing Conveyance and Loadout 6-19
6.3.10 Summary of Existing Solids System Evaluation 6-20
6.4 Long-Term Biosolids Stabilization Study....................6-23
6.4.1 Class A versus Class B Biosolids Discussion 6-24
6.4.2 Solids Stabilization Process Alternatives Evaluation....................6-30
6.4.3 Solids Thickening Alternatives Evaluation....................6-47
6.4.4 Solids Dewatering Process Alternatives Evaluation 6-56
6.4.5 Polymer System Optimization 6-59
6.5 Mineralogical Controls and Recovery 6-62
6.5.1 Deposition of Minerals....................6-62
6.5.2 Struvite Recovery 6-64
6.6 Cost Evaluation of Narrowed Alternatives....................6-65
6.7 Non-Economic Evaluation of Narrowed Alternatives 6-66
6.8 Summary of Solids Stream Recommendations 6-69
7 Existing Facility Site Improvements 7-1
7.1 Introduction 7-1
7.2 Objectives and Purpose 7-1
7.3 Maintenance Building....................7-1
7.4 Equalization Basin....................7-2
7.5 Odor Control....................7-2
7.5.1 Odor Control Technologies....................7-3
7.6 Influent Flow Measurement Improvements....................7-9
7.7 Effluent Flow Measurement 7-10
7.8 Wet Well Inspection and Coating....................7-11
7.9 Non-potable Water System Improvements 7-11
7.10 Dewatering Polymer Improvements 7-12
7.11 Solar Panels....................7-13
7.12 Economic Evaluation....................7-14
7.13 Recommendations 7-15
8 Monetary and Non-Monetary Evaluation....................8-1
8.1 Summary of Design Flows and Loads 8-1
8.2 Liquids Stream Monetary Evaluation 8-2
8.3 Solids Stream Monetary Evaluation 8-4
8.4 Existing Facility Site Improvements Monetary Evaluation....................8-6
8.5 Summary of Recommended Project Costs 8-7

8.6 Non-Monetary Evaluation 8-8
8.7 Conclusion 8-11
9 System Recommendations and Capital Improvements Plan 9-1
9.1 Introduction 9-1
9.2 Project Specific Permitting 9-1
9.3 Wastewater Infrastructure Improvements Program 9-2
9.3.1 Plant Expansion Project Phase 1 9-2
9.3.2 Miscellaneous Improvements Project (MIP) 9-5
9.3.3 Liquids Improvements Project Phase 1 (LIP1) 9-6
9.3.4 Liquids Improvements Project Phase 2 (LIP2) 9-7
9.3.5 Expansion Project Phase 2 (EP2) 9-8
9.3.6 Master Plan Updates 9-9
9.4 High-Level Project Cost Estimates 9-9
9.5 Proposed Wastewater Infrastructure Improvements CIP 9-9

Abbreviations

APCD	Air Pollution Control Division
AQCC	Air Quality Control Commission
ATAD	Autothermal Thermophilic Aerobic Digestion
BOD	Biochemical Oxygen Demand
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CFU	Coliform Forming Units
CIP	Capital Improvements Plan
CPLR	Cumulative Pollutant Loading Rates
EDCs	Endocrine-Disrupting Compounds
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FKC	Fukoku Kogyo Company
IFAS	Integrated Fixed-Film Activated Sludge
IPP	Industrial Pretreatment Program
LOMR	Letter of Map Revision
MACT	Maximum Achievable Control Technology
MFR	Manufacturer
MGD	Million Gallons per Day
MPN	Most Probable Number
NACWA	National Association of Clean Water Agencies
NAS	National Academy of Sciences
NFRWQPA	North Front Range Water Quality Planning Association
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
NWRF	Town of Erie North Water Reclamation Facility
O&M	Operation and Maintenance
PC	Pollutant Concentration
PEC	Pathogen Equivalency Committee
PSRP	Process to Significantly Reduce Pathogens
RAS	Recycle Activated Sludge
RDT	Rotary Drum Thickener
RST	Rotary Screen Thickener
SNDR	Storage Nitrification Denitrification Reactor
SSI	Sewage Sludge Incinerator
TIN	Total Inorganic Nitrogen
TN	Total Nitrogen
TNSSS	Targeted National Sewage Sludge Survey

TP	Total Phosphorus
TOrCs	Trace Organic Chemicals
TS	Total Solids
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
UV	Ultraviolet
VAR	Vector Attraction Reduction
WAS	Waste Activated Sludge
WERF	Water Environment Research Foundation
WET	Whole Effluent Toxicity
WQCC	Water Quality Control Commission
WQCD	Water Quality Control Division
WRF	Water Reclamation Facility

Contents

1 Executive Summary 1-1

1.1 Introduction 1-1

1.1.1 Existing Liquids Stream Process Description 1-1
1.1.2 Existing Solids Treatment Process Description 1-2

1.2 Basis of Planning 1-5

1.2.1 Summary of Previous Planning Studies 1-5
1.2.2 Basis of Alternatives Evaluation 1-5
1.2.3 Cost Estimating Methodology 1-6

1.3 Wastewater Characterization 1-6

1.3.1 Population Projections 1-6
1.3.2 Recommended Flows and Loads 1-7

1.4 Regulatory Drivers 1-8

1.5 Liquids Stream Process Performance Evaluation and Alternatives Analysis 1-13

1.5.1 Hydraulic Analysis 1-13
1.5.2 Liquids Stream Process Capacity and Condition Analysis 1-13

1.6 Solids Stream Process Performance Evaluation and Alternatives Analysis 1-15

1.6.1 Existing Solids System Evaluation 1-15
1.6.2 Long-Term Biosolids Stabilization Study 1-16

1.7 Existing Facility Site Improvements 1-18

1.8 Monetary and Non-Monetary Evaluation 1-19

1.8.1 Liquids Stream Monetary Evaluation 1-19
1.8.2 Solids Stream Monetary Evaluation 1-20
1.8.3 Existing Facility Site Improvements Monetary Evaluation 1-21
1.8.4 Summary of Recommended Project Costs 1-22
1.8.5 Non-Monetary Evaluation 1-23

1.9 System Recommendations and Capital Improvements Plan (CIP) 1-24

Tables

Table 1-1. Previous Studies Used for Comparison 1-5
Table 1-2. Recommended Population Projection Summary 1-6
Table 1-3. Summary of Recommended 10 and 20 Year Design Values 1-7
Table 1-4. Summary of Liquids Stream Expansions/Improvements Needed at Erie NWRF 1-14
Table 1-5. Summary of Solids Stream Expansions/Improvements Needed at Erie NWRF 1-15
Table 1-6. Total Anticipated Project Costs of Liquids Stream Expansion Alternatives 1-19
Table 1-7. Breakdown of Costs for Recommended Solids Stream Expansion 1-20
Table 1-8: Existing Facility Site Improvements Opinion of Probable Construction Cost 1-21
Table 1-9: Erie NWRF Expansion Project Opinion of Probable Construction Cost 1-22
Table 1-10: Liquids Stream Bid Alternates Opinion of Probable Construction Cost 1-23
Table 1-11. High-Level Budgetary Estimates for Anticipated Projects 1-25

Figures

Figure 1-1. Flow Diagram of NWRF Treatment System 1-3
Figure 1-2. Summary of Anticipated Regulatory Requirements 1-11
Figure 1-3: Non-Economic Evaluation of Narrowed Alternatives 1-24

Figure 1-4. Triggers and Improvements Projects..1-27
Figure 1-5. Projects Site Implementation..1-29

1 Executive Summary

1.1 Introduction

The Town of Erie owns and operates the North Water Reclamation Facility (NWRF) located just northeast of E. County Line Road and State Highway 52. The plant utilizes an Integrated Film Activated Sludge (IFAS) technology for secondary treatment, and discharges to either Erie's Reuse Reservoirs for reclaimed water and augmentation, or Boulder Creek for standard effluent discharge. The plant's lime/pasteurization solids treatment facility is intended to produce Class A biosolids. The facility was built in 2011 and was upgraded in 2017. Improvements included the following:

- New sheaves and motors to increase the capacity of the influent and internal recycle/Recycle Activated Sludge (RAS) pumps
- Addition of a second IR pump
- UV expansion
- Addition of a third blower
- Addition of airflow control valve actuators and control system
- Additional IFAS media to expand oxic capacity
- Addition of a liquid solids loadout facility
- Construction of a RAS control structure to better split flow to the bioreactor basins

The purpose of this master plan was to evaluate the liquids stream and solids stream treatment systems at the NWRF and provide capital improvement recommendations for the next 20 years. Additionally, a long-term biosolids stabilization alternatives analysis was performed to determine the best option for the long-term solids treatment process at the NWRF. Improvements are recommended for implementation based on one or more of the following criteria:

- Regulatory requirements
- Capacity requirements
- Condition requirements
- Operations requirements
- Sustainability

1.1.1 Existing Liquids Stream Process Description

The liquids stream treatment process at the Erie NWRF consists of screening and grit removal, followed by an IFAS secondary treatment process. This system uses a three-step biological process in which wastewater enters the two anaerobic zones in a parallel operation scheme, then flows to the anoxic zones, and is finally sent to the four aerobic zones. The existing aerobic zones have carrier media, which are small polyethylene fragments with a high surface area on which biomass is attached. This media reduces hydraulic retention time requirements in the reactors, allowing for smaller footprint requirements of the whole system. The internal recycle stream is pulled from directly downstream of the aerobic basins, from the splitter structure, and sent to the anoxic zones, and RAS is pulled from the secondary clarifiers and sent to the anaerobic zones.

After wastewater is passed through the IFAS system, it flows to the plant's two existing secondary clarifiers via a splitter structure. From the secondary clarifiers, flow can be sent either to a disc filter, and then to the ultraviolet (UV) system, or directly to the UV system. The NWRF is required to process flow through the disc filter when discharging to the reuse storage ponds, but not when discharging to Boulder Creek. However, staff have indicated that flow is always sent to the disc filter upstream of the UV system, regardless of which discharge is used.

1.1.2 Existing Solids Treatment Process Description

The NWRF's existing solids treatment process utilizes an alkaline biosolids stabilization process, provided by Fukoku Kogyo Company (FKC), to achieve Class A cake. Overall, the FKC Class A solids treatment system was designed to treat 6,120 dry pounds of biosolids per day.

The solids treatment process begins after the secondary clarifiers. Waste Activated Sludge (WAS) is pumped from the secondary clarifiers to a WAS holding tank, and then pumped to a lime tank. Here, lime is mixed with WAS until the slurry reaches a pH of higher than 12, to achieve Class A biosolids conditions required in Title 40 of the Code of Federal Regulations (CFR), Part 503, *Standards for the Use or Disposal of Sewage Sludge* (the "Biosolids Rule"). The WAS and lime slurry is pumped in parallel to the feed tanks, where the WAS and lime continue mixing. There are two feed tanks, providing approximately three and a half days of storage. The lime and biosolids must remain above a pH of 11.5 for 22 hours in these tanks to achieve a Class A biosolids classification. The slurry is then transferred from the feed tanks to an FKC rotary screen thickener (RST), where polymer is injected to promote flocculation, and the slurry is thickened from an average solids concentration of 1.5% total solids (TS) to an average of 10.4% TS. From the RST the thickened solids drop into the FKC screw press, and the biosolids are simultaneously pasteurized for 30 minutes retention time and dewatered, in order to meet the Class A requirements provided in the Biosolids Rule.

A process schematic of the entire Erie NWRF is shown in Figure 1-1.

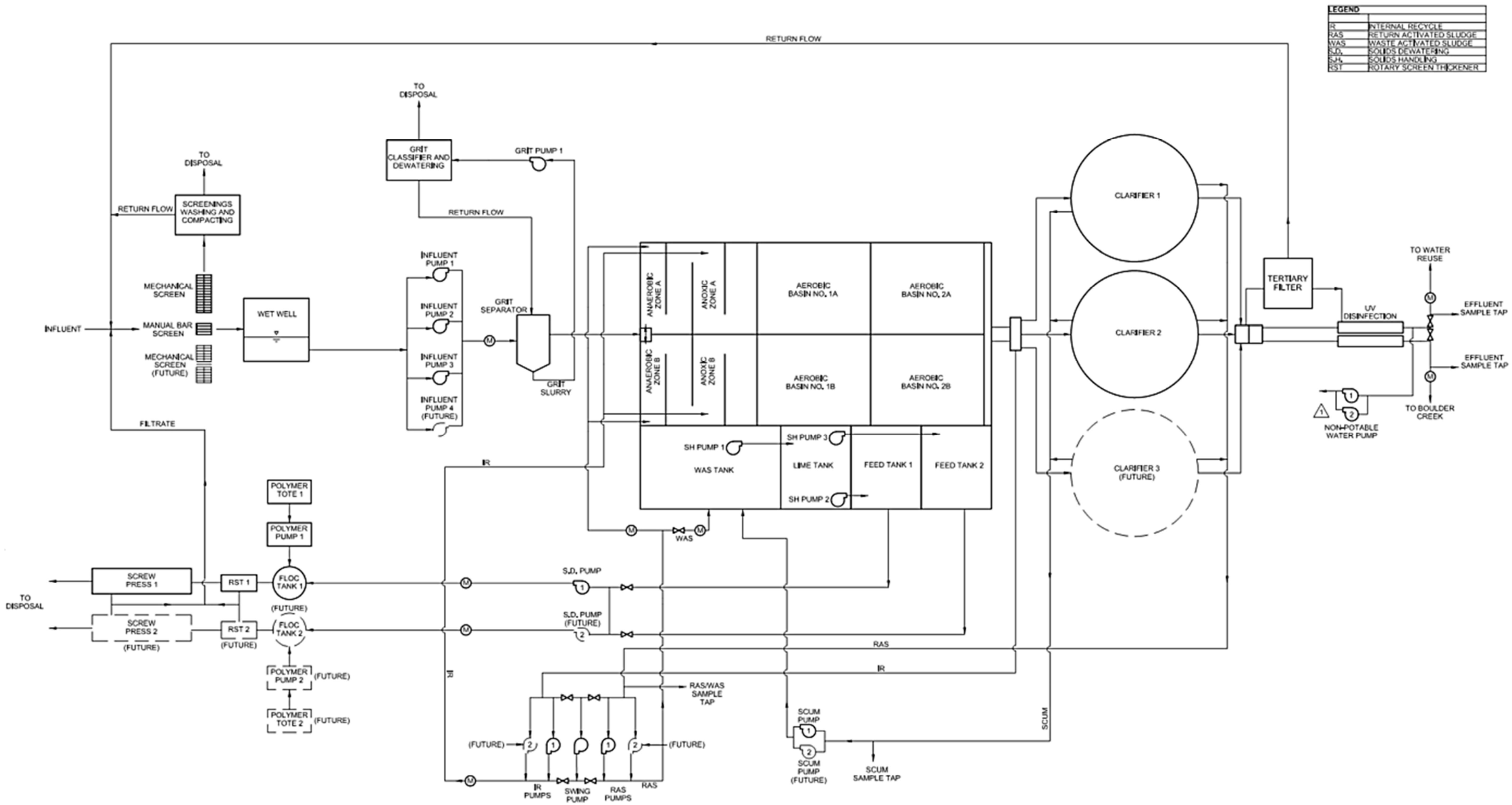


Figure 1-1. Flow Diagram of NWRF Treatment System

This page is intentionally left blank.

1.2 Basis of Planning

The purpose of this section is the following:

- Provide a summary of previous planning studies and recommendations.
- Provide a description of the basis of alternatives evaluation.
- Give a description of the cost estimating methodology used for all cost estimates in this Master Plan.

1.2.1 Summary of Previous Planning Studies

Multiple studies have been conducted over the past eight years pertaining to the Erie NWRF. A list of the relevant studies summarized in Chapter 2, and used for comparison of flows and loads developed by HDR, is provided in Table 1-1.

Table 1-1. Previous Studies Used for Comparison

Report Title	Date	Firm
Erie Wastewater Utility Plan	January 2013	Indigo Water Group
Erie Project Implementation Report For the Wastewater Reclamation Facilities	October 2014	Frachetti
Erie Wastewater Utility Plan Update	November 2015	Burns & McDonnell

In order to ensure that the basis of planning values are defensible, a summary of the key conclusions from each study is provided in Chapter 2.

In Chapter 3, the projected flows and loads values from each report are compared in depth to the influent flow and loading projections that HDR developed. However, a preliminary comparison of the reports listed above shows that the influent future flow values from each report is different, due to varying population growth rate projections, as well as varying per capita wastewater generation rates. Chapter 2 provides the comparison of population and maximum month flow projections between each study.

1.2.2 Basis of Alternatives Evaluation

The basis of alternative evaluation description provides an overview of the process HDR and Erie staff used to develop and narrow down alternatives. After brainstorming and screening a wide range of liquid stream and solids stream treatment alternatives, an initial screening phase was developed to eliminate alternatives that are fatally flawed or clearly unattractive compared to other remaining alternatives. This phase reduced the number of system-wide alternatives to a manageable number.

For evaluation of the short-listed alternatives, the project team chose a decision support method that allows a comparison of life-cycle costs against “non-cost” benefits. The steps included in this method as well as the non-monetary evaluation criteria the Erie/HDR team selected and applied are shown provided in Chapter 2. Chapter 6 discusses the non-economic evaluation performed for various solids stabilization alternatives.

1.2.3 Cost Estimating Methodology

All capital costs include allowances for sitework and yard piping; contractor mark-up; contingencies; and engineering, legal and administration costs. The cost estimating procedure is presented in Chapter 2. Appendix A contains the detailed cost estimates.

HDR calculated the 10-year net present value for the alternative to keep existing solids treatment equipment and systems as they currently are, and for the Autothermal Thermophilic Aerobic Digestion (ATAD) system alternative. Future costs are inflated at a rate of 2.2 percent. The nominal interest rate of 2.1 percent for a 10-year time period was used as published by the Executive Office of the President, 2017. Net present values were calculated using 2017 as the base year and extending into 2028.

HDR developed current operating costs for labor, energy, and chemicals, which are described and provided in Chapter 2.

1.3 Wastewater Characterization

Chapter 3 develops and provides the following:

- Current and future land use and population projections
- Current and future wastewater flows and loads

Average, maximum month, and peak hour flows and loads were projected for the next 20 years to provide the framework for an expected schedule of expansion improvements at the Town of Erie's NWRF.

1.3.1 Population Projections

Based on input from the Town of Erie, the recommended population projection rate is based on an 8% growth rate until 2022, and then 5% growth rate from 2023 and on. This projection method allows for conservative planning for the next five years, based on trends observed in recent years, but also prevents overestimating population growth in twenty years. Table 1-2 below provides a summary of the projected population values that are used as a basis of planning throughout the rest of this Master Plan for a number of years.

Table 1-2. Recommended Population Projection Summary

Year	Population Value	Yearly Percent Growth
2020	31,493	8%
2025	42,523	5%
2028	49,226	5%

Table 1-2. Recommended Population Projection Summary		
Year	**Population Value**	**Yearly Percent Growth**
2030	54,272	5%
2035	69,266	5%
2038	80,184	5%
Build-out (2034)	68,820	5%

The in-depth analysis of various population projection methods and the selection method for the recommended population projection is provided in Chapter 3.

1.3.2 Recommended Flows and Loads

Table 1-3 summarizes the design year (2028 and 2038) influent flows and loads that will be used as the overall basis for design. These values impact equipment sizing, as well as downstream processes as determined by the solids mass balance. These values serve as sizing criteria and will determine the required capacity for each design task in this Master Plan.

Table 1-3. Summary of Recommended 10 and 20 Year Design Values		
Parameter	**2028**	**2038**
Projected Population	49,226	80,184
Avg. Day Influent Flow (MGD)	2.80	4.56
Max. Month Influent Flow (MGD)[a]	3.03	4.93
Avg. Day Influent BOD Loading (lb/day)	6,997	11,398
Max Month Influent BOD Loading (lb/day)	9,376	15,273
Avg. Day Influent TSS Loading (lb/day)	7,193	11,717
Max Month Influent TSS Loading (lb/day)	9,709	15,815
Avg. Day Influent Ammonia Loading (lb/day)	840	1,368
Max Month Influent Ammonia Loading (lb/day)	1,114	1,814

Table 1-3. Summary of Recommended 10 and 20 Year Design Values		
Parameter	2028	2038
Avg. Day Influent TP Loading (lb/day)	443	722
Max Month Influent TP Loading (lb/day)	618	1,007
Max Month RAS Flow (MGD)[b]	3.03	4.93
Max Month RAS Flow (lb/day)[b]	346,202	563,291
Max Month WAS Flow (gpd)[b]	102,711	160,650
Max Month WAS Flow (lb/day)[b]	11,700	18,300
Max Month Dewatered Solids Flow (lb/day)[c]	14,040	21,960

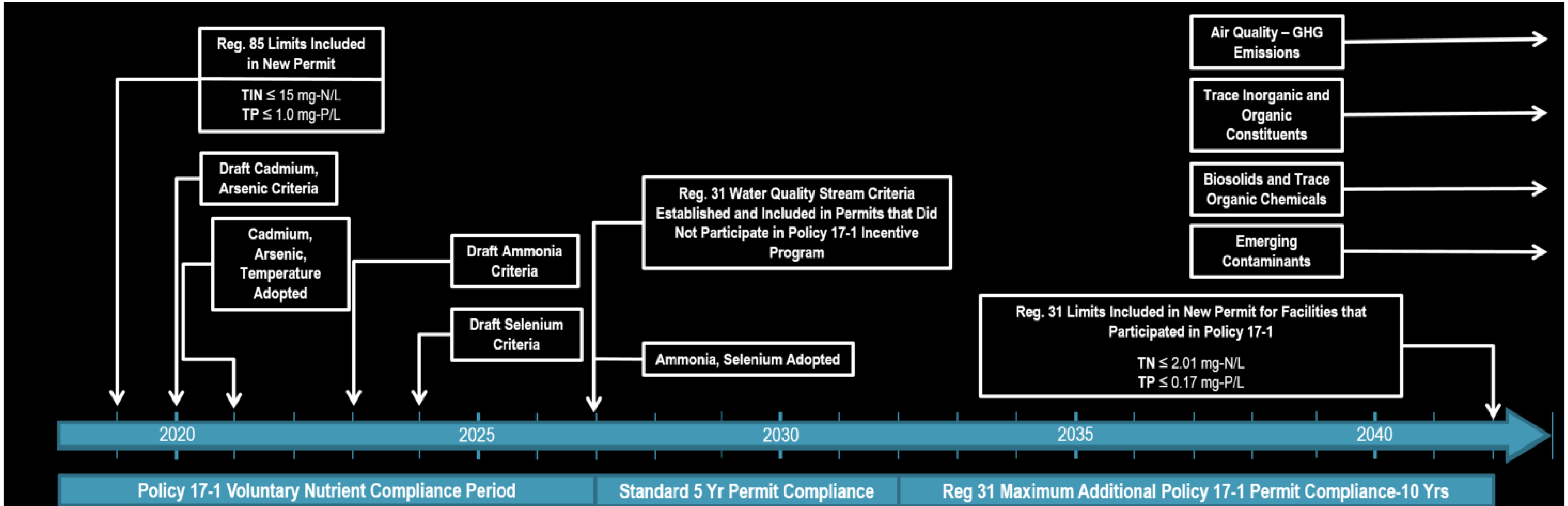
[a] Based on 61.5 gpcd wastewater generation rate per capita.
[b] Based on projected solids flow rates provided by Kruger. Assumes secondary treatment expansion.
[c] Assumes no change in existing solids treatment process. Based on a 1:5 ratio of lime to WAS solids use. See chapter 6.

1.4 Regulatory Drivers

Figure 1-2 provides a summary of the anticipated regulatory requirements, the associated permit cycles and challenges associated. Over the next 10 years, the Town will continue to participate in Colorado Department of Public Health and Environment's (CDPHE) Policy 17-1. By doing so, the Town can gain up to an additional 10 years of compliance schedule on top of the standard 5 years for meeting the requirements of Regulation 31. This is critical, as the total nitrogen (TN) limits currently documented are ***below*** the limits of what can reasonably be achieved with today's available treatment technologies. The extended compliance allows treatment technology to "catch up" to the water quality requirements and provides additional time to develop alternative methods for meeting the limits, including nutrient trading. Nutrient trading is a tool that can be used by facilities to meet stringent water quality standards, particularly for those facilities that receive large nutrient loads via point sources. This approach involves a facility reducing nutrient concentrations to a level below what is required by their permit, and them selling those additional reductions as credits to other facilities that struggle to meet their nutrient reduction requirements. Although this tool may be beneficial for smaller dischargers that cannot meet nutrient limits in a cost-effective manner, this tool has not yet been widely communicated to facilities or emphasized by the State, and it is considered "outside" of the typical approaches advocated by National Pollutant Discharge Elimination System (NPDES).

Based on the current regulatory environment for biosolids, it is anticipated that the industry will gravitate increasingly towards Class A biosolids throughout the next 10 to 15 years. Chapter 4 and Chapter 6 provide in-depth discussions concerning the potential changes to biosolids regulations in the future, as well as the potential risks associated with pursuing Class B biosolids production. The NWRF currently is experiencing issues with the solids processing system. The energy, time, and chemicals put into the system meet the Class A requirements; however, NWRF is achieving and hauling only Class B biosolids. The solids stream process performance chapter evaluates the solids treatment options and recommends whether a Class A or Class B product is viable.

As noted in Figure 1-2, ammonia, temperature, and other emerging contaminants will be evaluated and included in upcoming permits. It is recommended the Town participate in stakeholder groups during the process of developing the draft limits and provide comment to CDPHE.



	2019 – 2024	2024 - 2029	2029 - 2034	2034 - 2039	2039 - 2044
	Permit Cycle I	Permit Cycle II	Permit Cycle III	Permit Cycle IV	Future
Challenges	• Reg 85 TIN & TP included • Document effluent TIN/TP for Policy 17-1 credit • Primary Improvements Implemented – expand IFAS and construct solids handling • Miscellaneous facility improvements • Participate in stakeholder process for upcoming water quality issues	• Plan for lower ammonia criteria • Temperature compliance (site specific variance) • Cadmium and arsenic compliance • Improvements not included in phase 1 project • Participate in stakeholder process for upcoming water quality issues	• Lower ammonia criteria • Selenium compliance (site specific variance) • Energy use limits • WW master planning • Participate in stakeholder process for upcoming water quality issues	• Trace inorganic and organic constituents • Greenhouse gas limits • Energy use limits • Emerging contaminants • Develop plan for Reg 31 improvements • Design and construct expansion of IFAS and solids facilities as needed • Participate in stakeholder process for upcoming water quality issues	• Implement Reg 31 improvements • Water supply shortages • Continued infill of service area • WW master planning • Participate in stakeholder process for upcoming water quality issues

Figure 1-2. Summary of Anticipated Regulatory Requirements

This page is intentionally left blank.

1.5 Liquids Stream Process Performance Evaluation and Alternatives Analysis

Chapter 5 presents a liquids stream capacity and condition analysis that concludes with a set of improvement recommendations to accommodate future flows and loads. Goals of this evaluation include:

- Perform hydraulic analysis that models the NWRF's liquids stream treatment process, run the model under a number of flow scenarios, and identify hydraulically-limited components of the system.
- Evaluate the total and firm existing treatment and hydraulic capacities of the NWRF liquids stream processes.
  - Liquids stream processes include influent pumping, headworks, IFAS basins, blowers, secondary clarifiers, UV disinfection, and tertiary filters
- Compare future flow and loading demands, provided in Chapter 3, to the rated capacity of the existing unit processes. Consider future equipment capacity required for flow demand, treatment requirements, and process redundancy. Identify capacity restrictions in the liquids stream unit processes, and determine when they will occur.
- Develop a set of recommended process expansions and improvements that are necessary to meet the anticipated influent flows and loads demands within a 20 year planning frame, as well as CDPHE Regulation 85 end-of-pipe nutrient limits, and CDPHE Regulation 31 in-stream nutrient limits.
- Include recommendations for minor equipment/control revisions that will allow the plant to continue operation during planning and design.

1.5.1 Hydraulic Analysis

A hydraulic analysis was performed on the liquid stream system of NWRF using the Visual Hydraulics© program. The model was used to simulate NWRF operating at the 2028 peak hour flow of 5.6 million gallons per day (MGD). The goal of the evaluation was to determine if the proposed plant expansion could accommodate peak hour flow of 5.6 MGD. Two levels of failure were investigated for each scenario: a process control failure and a catastrophic failure. A process control failure occurs when a weir is flooded and the flow split between process trains is no longer controlled. A catastrophic failure occurs when a process overflows.

Five distinct NWRF scenarios were modeled. The exact model configurations and the results of each modeling scenario are included in Chapter 5. In general, the Visual Hydraulics© model shows that in all configurations, the plant can accommodate the peak hour flow of 5.6 MGD without risk of overflow.

1.5.2 Liquids Stream Process Capacity and Condition Analysis

In Chapter 5, the existing liquids treatment equipment capacities were evaluated for both firm and total capacity at 2028 and 2038 design years. Firm capacity is defined as the equipment capacity required to meet necessary flow demand and provide one standby unit for maintenance and downtime, and total capacity is defined as the capacity of all equipment without standby.

Once the equipment firm and total capacities were evaluated and compared to the 2028 firm capacity and 2038 total capacity requirements, each equipment piece in the solids treatment system was categorized into one of three priority tiers:

- Primary Priority: Equipment improvements or additions that are required to meet 2028 firm capacity. To meet 2028 firm capacity, the equipment capacity must meet its necessary flow demand, which is the 2028 design flow value provided in Section 1.3, while also having a separate unit available for standby.
- Secondary Priority: Equipment improvements or additions that are not strictly mandatory for the next phase of expansions at the NWRF, but that will be required prior to 2028, in order to meet 2028 firm capacity needs.
- Tertiary Priority: Equipment improvements or additions which can further provide redundancy or capacity, ease maintenance, increase robustness, reduce equipment downtime, reduce risk of permit violations, and reduce emergency overnight work.

This analysis resulted in a categorized list of improvements or expansions required at the Erie NWRF. A summary of the results of this liquids system capacity analysis is provided in Table 1-4.

Table 1-4. Summary of Liquids Stream Expansions/Improvements Needed at Erie NWRF

Primary Priority	Secondary Priority	Tertiary Priority
• 2nd Grit System • 3rd IFAS Basin • Addition of Anoxic and Re-aeration Zones on Each Basin • RAS/IR Separation • Addition of new internal recycle (IR) in-basin pumps • Grit Pump • Fourth Influent Pump	• Aeration Capacity Addition with Blowers • Grit Dewaterer/Classifier	• Headworks Screen • 2nd Disc Filter[a]

a. Indoor versus outdoor location to be determined during predesign, if this item is included in the NWRF's next expansion project.

The cost analysis of several combinations of liquids stream improvements, the non-economic evaluation discussion, and the final list of recommendations for the liquids stream improvements are provided in Chapter 5 and in later sections of this chapter.

1.6 Solids Stream Process Performance Evaluation and Alternatives Analysis

Chapter 6 evaluates the existing solids treatment processes at the NWRF to determine the solids treatment process capacity and efficiency. Additionally, new solids stabilization alternatives for increased flows and loads are evaluated to determine the best option for the Town. Various aspects of a functioning solids treatment system, including the performance, chemical usage, energy requirements, operation and maintenance needs, as well as the truck loading and hauling system are compared for all alternatives, and methods for optimizing each are discussed.

1.6.1 Existing Solids System Evaluation

The solids system capacity analysis goals and methodology are the same as those for the liquids system capacity and condition analysis, provided in Chapter 5. The goal of the existing solids stream capacity analysis was to generate a high-level solids process equipment condition assessment, as well as a broad timeline of solids treatment equipment replacement and/or expansion. To this end, the existing solids treatment equipment capacities were evaluated for both firm and total capacity at 2028 and 2038 design years. Once the equipment firm and total capacities were evaluated and compared to the 2028 firm capacity and 2038 total capacity requirements, each equipment piece in the solids treatment system was categorized into one of three priority tiers, which were described and defined earlier.

Table 1-5 below provides the recommended categorization of expansions and improvements needed at the Erie NWRF, based on the recommended solids process. These recommendations and their respective categorizations are a culmination of the capacity analysis provided in Chapter 6, but they also incorporate input provided by the Town of Erie staff.

Table 1-5. Summary of Solids Stream Expansions/Improvements Needed at Erie NWRF

Primary Priority	Secondary Priority	Tertiary Priority
• New ATAD Facility for 2028 conditions[a] • Solids dewatering pump • New WAS thickening unit • Enclose lean-to structure for solids storage • Distribution screw • Solids storage tank lining[b]	• Second new WAS thickener	• SH pump feeding solids from WAS tank to Lime tank • Landia jet mixers

Table 1-5. Summary of Solids Stream Expansions/Improvements Needed at Erie NWRF		
Primary Priority	Secondary Priority	Tertiary Priority

a. See further discussion below on evaluation leading to ATAD recommendation.
b. Exact blasting/coating/lining requirements for solids storage tanks to be determined based on complete condition assessment of tanks.

1.6.2 Long-Term Biosolids Stabilization Study

The objective of the long-term biosolids stabilization study is to provide an alternatives analysis of several biosolids stabilization technologies. This analysis provided in Chapter 6 addresses Class A and Class B stabilization technologies, as well as solids thickening technology alternatives, solids dewatering equipment alternatives, and cake handling options. The outcome of the long-term biosolids stabilization study was a selection of the most viable solids stabilization technology for the Erie NWRF, based on performance, cost, and a number of non-economic criteria. Related components of the solids handling system, such as thickening, dewatering, centrate management, and cake handling, were also considered and evaluated for feasibility.

Solids Stabilization Process Alternatives Evaluation

Due to the number of issues the NWRF has had with their existing solids processing equipment and pipe scaling throughout the plant, the Town is interested in a functional biosolids stabilization system. Chapter 6 provides a screening level alternatives analysis for biosolids stabilization technologies. The technologies discussed include:

- Aerobic digestion
- Solar Greenhouse Drying with Supplemental Heat
- BCR Chemical Biosolids Stabilization
- Autothermal Thermophilic Aerobic Digestion (ATAD)
- Intergovernmental Agreement
- Hauling of Biosolids to a Landfill
- Alkaline Biosolids Stabilization with Lime

The intended outcome of this screening level analysis was to establish a narrowed list of biosolids stabilization alternatives that undergo economic and non-economic comparison for further deliberation. After completing the preliminary screening of biosolids stabilization alternatives and evaluating the relative advantages and disadvantages of each, as provided in Table 6-4, HDR and Town of Erie staff eliminated the following technologies from further consideration:

- Aerobic Digestion
- Solar Greenhouse Biosolids Drying with Supplemental Heat
- Intergovernmental Agreement
- Hauling Biosolids to a Landfill
- Alkaline Biosolids Stabilization: Existing System Modification
- Alkaline Biosolids Stabilization: RDP Lime Stabilization
- Alkaline Biosolids Stabilization: Schwing Bioset System
- BCR CleanB

The following stabilization systems were evaluated further with an economical and non-economical evaluation:

- BCR Neutralizer
- Autothermal Thermophilic Aerobic Digestion (ATAD)

The economical and non-economical evaluation of these alternatives are provided in detail in Chapter 6.

Solids Thickening Alternatives Evaluation

As part of the long-term biosolids stabilization study, it is important that ancillary equipment is given due consideration. Therefore, Chapter 6 evaluates alternatives for producing a robust and reliable WAS thickening system. The evaluated alternatives include:

- Keeping and reusing the existing FKC rotary screen thickener
- Gravity belt thickeners
- Disc thickeners
- Rotary drum thickeners
- Screw presses
- Volute thickeners
- Centrifuges

This analysis provides an overview of each equipment, their primary thickening mechanisms, and their strengths and weaknesses. Based on the results of this analysis, HDR recommends the following steps for final selection of a thickening unit:

- Confirm selection of the plant's biosolids stabilization technology, and obtain input from manufacturer (MFR) regarding desired total solids concentration in stabilization system feed.
- Perform pilot testing with available technologies to confirm their performance with the NWRF's WAS material.
- Conduct site visits as necessary to familiarize staff with various thickening technologies.
- Determine the location and layout of thickening units during the next expansion project design. Consider equipment footprints.

Solids Dewatering Process Alternatives Evaluation

Similar to the WAS thickening technology evaluation, it is important that the dewatering equipment technologies are evaluated as well. The new or altered biosolids stabilization process at the NWRF will result in an altered sludge product being sent to the plant's dewatering process. Therefore, various dewatering alternatives are evaluated in this section to determine the most appropriate technology for the NWRF. Evaluated alternatives include:

- Keeping the existing FKC dewatering screw press
- Centrifuges
- Belt presses

Chapter 6 provides overviews of each equipment, their primary dewatering mechanisms, and their strengths and weaknesses. HDR recommends the following next steps towards selection:

- Confirm selection of the plant's biosolids stabilization technology, and obtain input from MFR regarding technology with which it performs best.
- Perform pilot testing with available technologies to confirm their performance with the NWRF's biosolids.
- Conduct site visits as necessary to familiarize staff with various dewatering technologies.
- Determine the location and layout of dewatering units during the next expansion project design.
- Consider advantages/increased efficiencies associated with standardizing biosolids dewatering equipment with the Erie Water Treatment Plant (WTP) dewatering equipment.

The cost analysis of the narrowed biosolids stabilization technologies, the non-economic evaluation discussion, and the final list of recommendations for the solids stream improvements are provided in Chapter 6 and in later sections of this chapter.

1.7 Existing Facility Site Improvements

The purpose of Chapter 7 is to provide technical expertise and cost estimates for resolving issues with miscellaneous sections of the treatment plant. The details of each set of improvements, along with their economic evaluation, are provided in Chapter 7. Overall, the recommendations of the miscellaneous items described include:

- Inspect and coat the influent wet wells in the headworks facility.
- Repair solids storage tanks concrete. (Details of this task are provided in Chapter 6.)
- Provide a maintenance building under a separate project.
- It is not recommended to provide an EQ basin.
- A permanent polymer transfer system will be included in the design of a dewatering facility.
- Separate odor control systems are recommended for the headworks and the solids treatment processes.
- Provide activated carbon filters on the exhaust fan system in the headworks.
- Provide a biological odor control system for the solids treatment processes.
- Include SCADA and electrical wiring in the construction project for the upstream influent flow measurement.
- Provide larger non-potable water system pumps and flow meters at process points.
- Provide a parshall or Palmer-Bowles flume for effluent flow measurement.
- Solar power is not recommended for this project; however, the Town may connect with a third party and explore the option of a PPA.

1.8 Monetary and Non-Monetary Evaluation

Chapter 8 summarizes the monetary and non-monetary evaluations for all recommended improvements and expansions to be performed in the NWRF's next expansion project. A summary of planning level cost estimates for the liquids stream, solids stream, and miscellaneous existing facility improvements is provided in this chapter, as well as an expected planning level cost for the entire project. Lastly, the non-monetary evaluation for the long-term biosolids stabilization alternatives is provided in this chapter as well.

1.8.1 Liquids Stream Monetary Evaluation

A summary of the recommended liquids stream expansion and improvement measures sorted by priority are in Table 1-4 above. At the very least, the items listed as a "primary priority" should be included in the next expansion project at the NWRF. The items listed as secondary or tertiary priorities should be included as bid alternates for the next expansion project, and included only if budget allows.

The monetary evaluation for the liquids stream improvements included four liquids stream expansion alternatives: IFAS expansion with primary priorities, IFAS expansion with primary and secondary priorities, IFAS expansion with primary, secondary, and tertiary priorities included, and the second disc filter located indoors, and lastly IFAS expansion with primary, secondary, and tertiary priorities included, and the disc filter located outdoors. Table 1-6 below provides a summary of the cost estimates for each of these liquids stream expansion alternatives.

Table 1-6. Total Anticipated Project Costs of Liquids Stream Expansion Alternatives

Alternative	Total Anticipated Project Cost (TAPC)
IFAS Expansion with Primary Priorities	$8,974,000
IFAS Expansion with Secondary Priorities	$10,086,000
IFAS Expansion with Tertiary Priorities (Expand Dewatering/UV Building)	$11,858,000
IFAS Expansion with Tertiary Priorities (No expansion of Dewatering/UV Building)	$11,702,000

The overall project costs included in Section 1.8.4 assume that the project will include only primary priorities for liquids stream expansions and improvements, and that the secondary and tertiary priorities will be included as bid alternates. Detailed cost estimates for all improvements recommended in this Master Plan are included in Appendix A.

1.8.2 Solids Stream Monetary Evaluation

For the existing solids stream capacity expansion, the following recommendations were provided for inclusion in the next expansion project at the NWRF:

- New solids dewatering pump
- Improved/expanded WAS thickening process
- Lean-to structure for solids storage
- Distribution screw for dewatered solids
- Solids storage tank inspection and lining

Additionally, for the long-term biosolids stabilization process at the NWRF, the following recommendations were provided:

- Implement ATAD as new biosolids stabilization process for Class A biosolids at Erie NWRF. Install a new biosolids stabilization facility sized for 2028 conditions, with two ThermAer tanks, one Storage Nitrification Denitrification Reactor (SNDR) tank, a biofilter, building space for ancillary equipment, and leave room for expansion to 2038 conditions.
- Demolish FKC dewatering screw press and install a new dewatering system with redundant units in the Dewatering Building. The dewatering technology selection should be further evaluated during the next expansion project predesign.
- Install new polymer system with mixing/aging tank for emulsion polymer. Consider a dry polymer system for use during the winter.

Table 1-7 below provides a summary of the cost estimates for the recommended solids stream improvements and expansions.

Table 1-7. Breakdown of Costs for Recommended Solids Stream Expansion

Item	Cost
General Conditions Subtotal	$767,000
Sitework Subtotal	$153,000
Concrete Subtotal	$1,428,000
Masonry Subtotal	$239,000
Metals Subtotal	$10,000
Thermal and Moisture Protection Subtotal	$135,000
Doors and Windows Subtotal	$32,000
Finishes Subtotal	$30,000
Equipment Subtotal	$4,527,000
Special Construction Subtotal	$125,000
Mechanical Subtotal	$183,300

Electrical and Instrumentation Subtotal	$806,000
TOTAL DIRECT COSTS SUBTOTAL	**$8,435,000**
TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL (Includes 30% Contingency and 10% for General Contractor Overhead, Profit, and Risk)	**$12,063,000**
TOTAL ANTICIPATED PROJECT COST (TAPC) (Includes Engineering Design, Construction Services, Permits, and 5% Town Project Contingency)	**$15,202,000**

Chapter 6 and Chapter 8 also provide a summary of the net present value analysis performed for the Keep Existing and ATAD solids stabilization alternatives.

1.8.3 Existing Facility Site Improvements Monetary Evaluation

A summary of opinions of probable costs for the existing site improvements are presented in Table 1-8. Dewatering Building odor control cost estimate is not included in this section since the recommendation is to combine the dewatering with solids stabilization odor control system and is included in the solids stream improvements cost estimate. Additionally, the solids storage tanks concrete repairs are not included in the summary of costs below, since that cost is also included in the solids stream improvements cost estimate. Similar to cost estimates provided for liquids and solids stream improvements, the cost estimates provided in the table below use the following assumptions:

- Costs were developed based on five digit specification divisions (i.e. Division 1, 2, etc…)
- 30 percent estimating contingency
- 10 percent contractor overhead and profit
- 20 percent engineering design/construction services
- 5 percent project contingency
- Provided as a “Total Anticipated Project Cost” which include all the above items

See Appendix A for detailed cost estimates for the existing facility site improvements.

Table 1-8: Existing Facility Site Improvements Opinion of Probable Construction Cost

Town of Erie - NWRF Master Plan Existing Site Miscellaneous Improvements Summary	
Description	**Budgeted Construction Cost**
Headworks Odor Control Improvements	$34,000
Influent Flow Measurement	$44,000

Effluent Parshall Flume	$37,000
Wet Well Inspection and Coating	$61,000
Non-potable Water System Improvements	$158,000
Dewatering Polymer Improvements	$21,000
TOTAL DIRECT COSTS SUBTOTAL	**$355,000**
TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL (Includes 30% Contingency and 10% for General Contractor Overhead, Profit, and Risk)	**$507,000**
TOTAL ANTICIPATED PROJECT COST (TAPC) (Includes Engineering Design, Construction Services, Permits, and 5% Town Project Contingency)	**$650,000**

1.8.4 Summary of Recommended Project Costs

In order to provide a planning level cost estimate for the entire expansion project at the NWRF, the costs for the solids stream, liquids stream, and existing facility improvements were all added, and are presented below in Table 1-9.

Table 1-9: Erie NWRF Expansion Project Opinion of Probable Construction Cost

Item	Cost
IFAS Expansion with Primary Priorities	$8,974,000
Solids Stream Improvements (Existing Capacity Expansion and ATAD)	$15,202,000
Existing Facility Site Improvements	$650,000
TOTAL ESTIMATED PROJECT COST	**$24,826,000**

This total project cost estimate assumes that only the primary priorities in the liquids stream expansion are provided in the base project scope. However, the secondary and tertiary priorities may be added as bid alternates for inclusion in the next NWRF expansion project as budget allows. Table 1-10 below shows the potential added costs if the secondary and tertiary priority improvements are added to the liquids stream expansion portion of this project.

Table 1-10: Liquids Stream Bid Alternates Opinion of Probable Construction Cost	
Item	**Cost**
Secondary Priorities (blower replacement and second grit dewaterer/classifier)	$1,112,000
Secondary and Tertiary Priorities (secondary priorities, headworks mechanical screen, and second disc filter located in expanded building)	$2,884,000
Secondary and Tertiary Priorities (secondary priorities, headworks mechanical screen, and second disc filter located outdoors)	$2,728,000

The detailed cost estimates for both the bid alternate options, as well as the line items in Table 1-9 above, are provided in Appendix A.

1.8.5 Non-Monetary Evaluation

The non-economic evaluation plays a key role in the selection process. It captures the criteria that are not associated with cost, but that are important for ensuring that the new biosolids stabilization alternative is implemented as seamlessly as possible at the NWRF. For the non-economic evaluation of the solids stream alternatives, HDR compared the solids stream alternatives based on a number of criteria described in Chapter 8:

- Operator attention
- Operator Familiarity
- Maintenance Requirements and Complexity
- Flexibility to Meet Future Flows and Loads Needs
- Footprint
- Implementability
- Redundancy
- Robustness/Long-Term Sustainability
- Safety

Each criterion was assigned a rating from 1 to 5, with 5 being the highest (best) rating attainable. The ratings were then added and divided by the total possible score to define a weighted score for each alternative. The ratings presented in Chapter 6 and again below were developed by HDR and presented to the Town of Erie staff to confirm agreement with the results.

The non-economic evaluation for the solids stream alternatives was based on scoring of each criterion, applying a weighting factor, and calculating a “total benefit” for each alternative. The determination of weighting factors are explained in Chapter 6. The “total benefit” values, coupled with the economic analysis, provide an overview of the relative costs and benefits for each alternative. The detailed scoring for the non-economic evaluation shown below is provided in Appendix B.

The weighted benefit scores for the solids stream alternatives are shown in Figure 1-3.

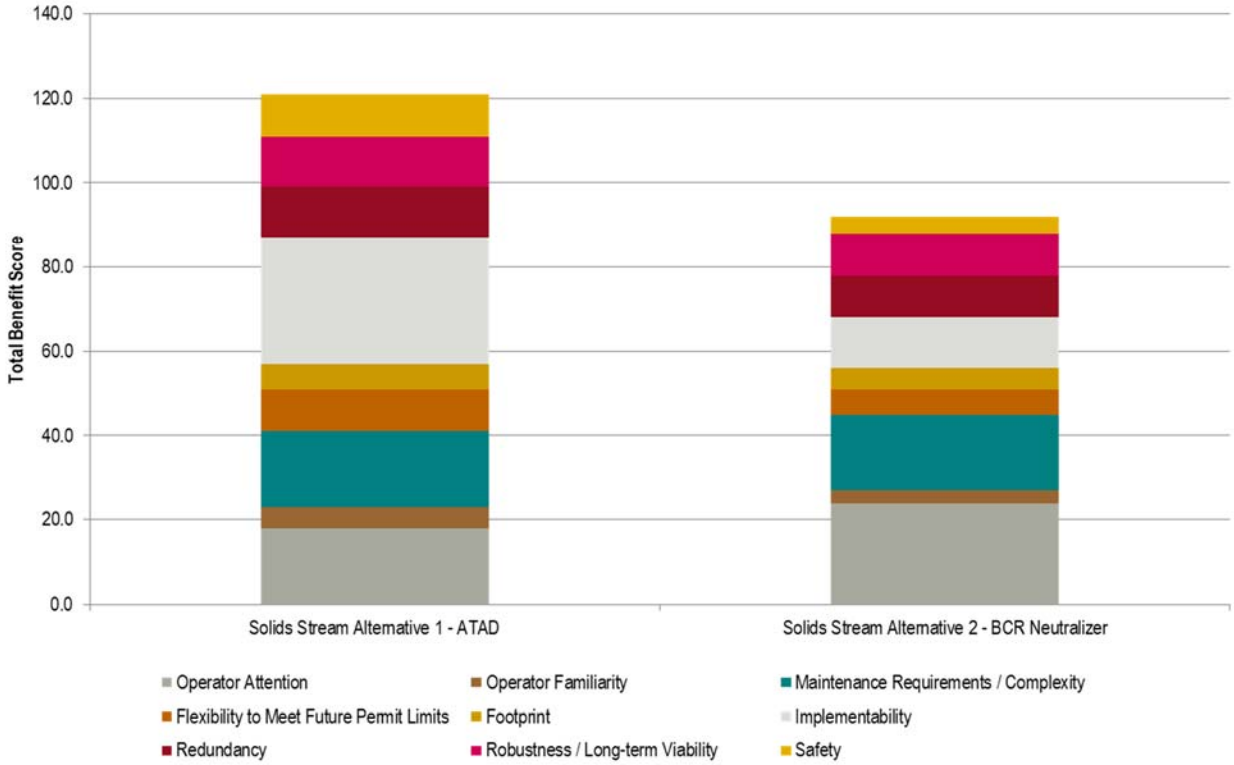


Figure 1-3: Non-Economic Evaluation of Narrowed Alternatives

As explain in detail in Chapter 5, a non-economic evaluation was not performed for the liquids stream expansion alternatives. The liquids stream expansion alternatives are generally all variations of the same process and technologies, which makes a non-economic evaluation less applicable and of limited value for the liquids stream improvements, because the alternatives differ only by the extent of expansions that the Town's budget will allow for.

1.9 System Recommendations and Capital Improvements Plan (CIP)

The goals for the Wastewater Infrastructure Improvements Program includes improving liquids and solids treatment processes, while adapting to changes associated with aging infrastructure, increased influent flows and loads projections, and long-term regulatory conditions. This CIP has organized the improvements into five projects spread over the next 20+ years:

- Plant Expansion Project Phase 1 (EP1)
- Miscellaneous Improvements Project (MIP)
- Liquids Improvements Project Phase 1 (LIP1)
- Liquids Improvements Project Phase 2 (LIP2)
- Expansion Project Phase 2 (EP2)

A description of each of the Wastewater Infrastructure Improvements Program Projects is included in Chapter 9, along with definitions of the recommended projects and studies that make up each project.

HDR provided a high-level cost estimate for each of the projects listed and discussed above, in order to give the Town a general idea for the order of magnitude costs for each project. Table 1-11 below shows a summary of anticipated project costs.

Table 1-11. High-Level Budgetary Estimates for Anticipated Projects

Item	Cost Estimate
Plant Expansion Project Phase 1	$25M
Miscellaneous Improvements Project	$1M
Liquids Improvement Project Phase 1	$5M
Liquids Improvement Project Phase 2	$1M
Plant Expansion Project Phase 2	$15M
Master Plan Update[a]	$200K[a]

a. This estimate represents the cost per single Master Plan Update

Lastly, HDR developed a proposed wastewater infrastructure improvements CIP for the Erie NWRF based on the recommended projects noted previously. Figure 1-4 provides the triggers, drivers, permit phasing and proposed projects. Triggers and/or drivers associated with a specific project are color coded. The proposed layout of the facilities identified in the CIP is shown on Figure 1-5. Project numbers are shown on the map with a description in the key.

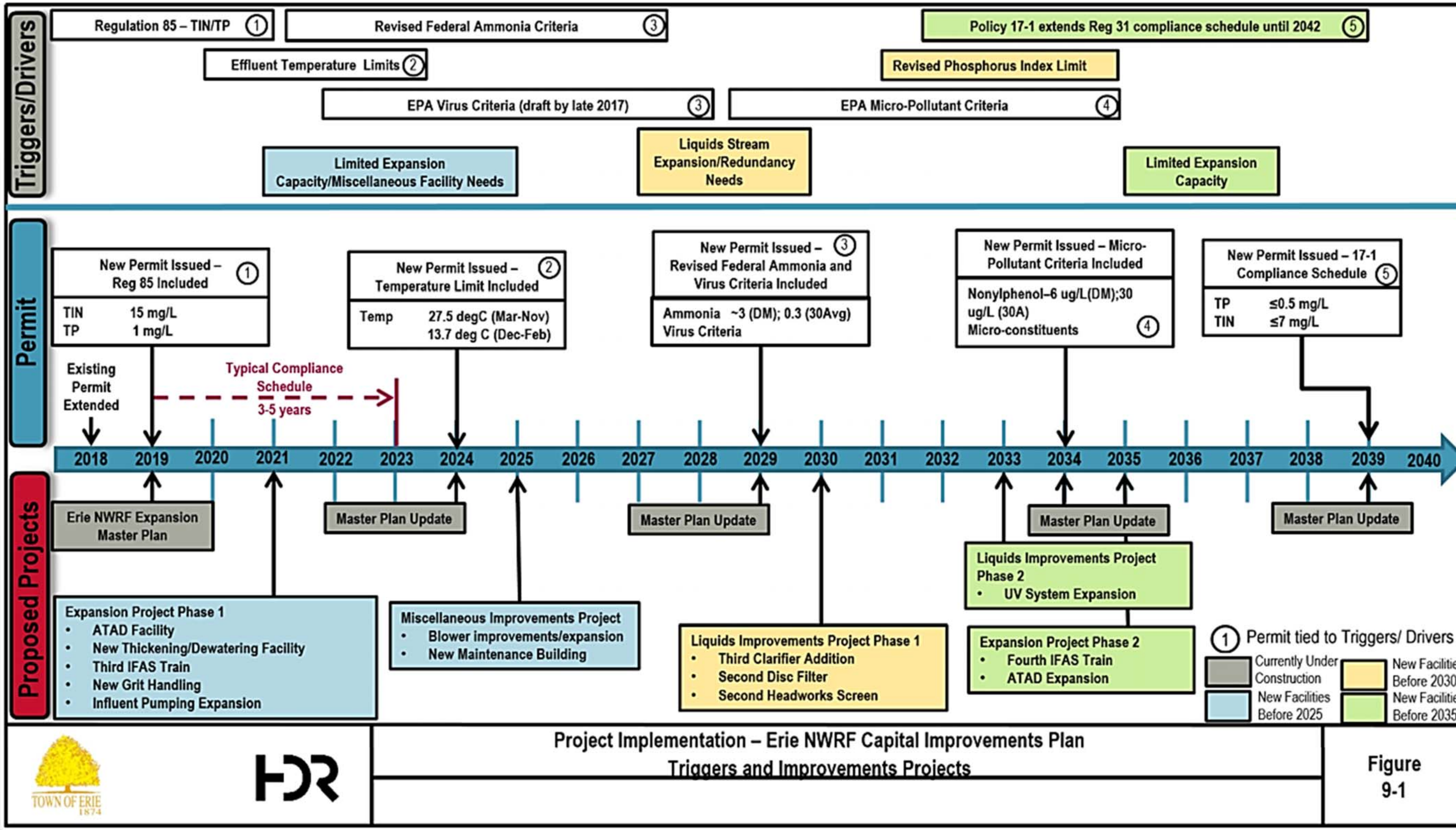


Figure 1-4. Triggers and Improvements Projects

This page is intentionally left blank.

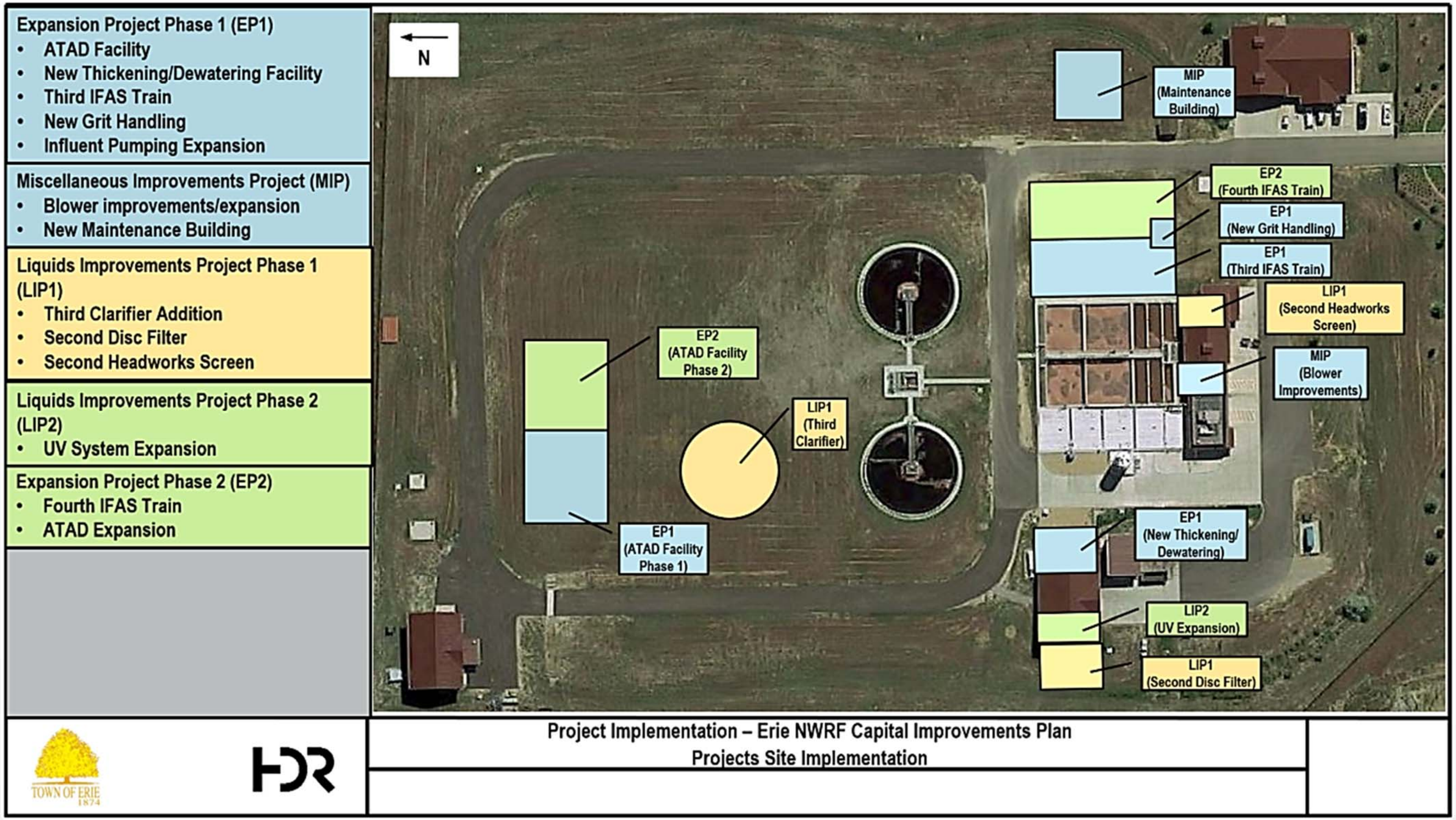


Figure 1-5. Projects Site Implementation

This page is intentionally left blank.

Contents

2 Basis of Planning 2-1
2.1 Introduction 2-1
2.2 Summary of Previous Planning Studies 2-1
2.2.1 Town of Erie 2013 Wastewater Utility Plan 2-1
2.2.2 Town of Erie 2014 Project Implementation Report 2-4
2.2.3 Town of Erie 2015 Wastewater Utility Plan Update 2-5
2.2.4 Preliminary Comparison of Erie Population and Flow Projections 2-7
2.3 Basis for Master Plan Guiding Principles 2-8
2.4 Basis of Alternatives Evaluation 2-11
2.4.1 Evaluation Methodology 2-11
2.4.2 Evaluation Criteria 2-12
2.5 Cost Estimating Methodology 2-14
2.5.1 Capital Costs 2-15
2.5.2 Inflation and Discount Rate 2-16
2.5.3 Operating Costs 2-16

Tables

Table 2-1. Previous Studies Used for Comparison 2-1
Table 2-2. 2013 Wastewater Utility Plan – Population Projections for the Town of Erie 2-2
Table 2-3. 2013 Wastewater Utility Plan – Erie NWRF Flow Projections 2-3
Table 2-4. 2013 Wastewater Utility Plan – Future Loads for Town of Erie from Historic Generation Rates 2-3
Table 2-5. 2014 Project Implementation Report - NWRF Projected Flows and Loads 2-4
Table 2-6. 2014 Project Implementation Report - Erie NWRF Projected Flows and Loads Summary 2-5
Table 2-7. 2015 Wastewater Utility Plan Updates – Updated Population Projections for the Town of Erie 2-6
Table 2-8. 2015 Wastewater Utility Plan Updates – Design Year 2023 Flows and Loads Projections 2-6
Table 2-9. 2013 and 2015 Wastewater Utility Plan – Population and Flow Projections for the Town of Erie 2-7
Table 2-10. Town of Erie Expansion Master Plan Guiding Principles and Scenarios Summary 2-9
Table 2-11. Non-Economic Evaluation Criteria 2-13
Table 2-12. Illustration of Capital Cost Estimating Procedure 2-15
Table 2-13. Chemical Cost Breakdown 2-17

This page is intentionally left blank.

2 Basis of Planning

2.1 Introduction

The purpose of this chapter is the following:

- Provide a summary of previous planning studies and recommendations.
- Provide a description of the basis of alternatives evaluation.

2.2 Summary of Previous Planning Studies

Multiple studies have been conducted over the past eight years pertaining to the Erie NWRF. A list of the relevant studies used for comparison of flows and loads is provided in Table 2-1. It is important to examine these studies and compare their projected design flows and loads to those developed by HDR. These projected design values have impacts on the schedule and feasibility of the recommended expansion plans moving forward, so any differences between the basis of planning presented in this chapter and the basis of planning used for past studies and designs should be acknowledged and explained. Rationale needs to be provided for why those changes exist, in order to ensure that the basis of planning values are defensible. To this point, a summary of the key conclusions from each study follows, and the projections from each report listed below are compared to those developed by HDR in Chapter 3.

Table 2-1. Previous Studies Used for Comparison

Report Title	Date	Firm
Erie Wastewater Utility Plan	January 2013	Indigo Water Group
Erie Project Implementation Report For the Wastewater Reclamation Facilities	October 2014	Frachetti
Erie Wastewater Utility Plan Update	November 2015	Burns & McDonnell

2.2.1 Town of Erie 2013 Wastewater Utility Plan

This report, written by Indigo Water Group, consolidated information from previous planning efforts and provided support for a modification to Erie's Section 208 water quality management planning boundary. The primary purpose for modification to the 208 boundary was so that the Town could ensure maximum capture of wastewater for non-potable reuse. In order to facilitate maximum water reuse, potable water sent to consumers from the Town's water treatment plant must return as wastewater to the Town's NWRF. This report also summarizes the basis of design for the NWRF plant expansion, including proposed design flows and loads, hydraulic and organic capacities, environmental conditions, anticipated effluent limits and treatment goals, and future expansion phasing considerations at the Town. The report was updated in 2015 by

Burns & McDonnell with actual population numbers from 2015.Those updates are discussed further in Section 2.2.3.

Population and Flow Projections

The population and influent flow rate projections were based on a compounded 6 percent annual average population growth rate from 2010 to 2017, and 4 percent growth rate from 2017 until build-out. The resultant population projections are shown below in Table 2-2.

Table 2-2. 2013 Wastewater Utility Plan – Population Projections for the Town of Erie

Year	2013 Population Projections
2010	18,135
2015	26,525
2020	33,525
2025	40,680
2030	49,625
Build-out	68,820

The values used as a basis of design are summarized below in Table 2-3. The influent flows were calculated based on an average day wastewater generation per capita value of 90 gpcd, and a maximum month wastewater generation per capita value of 118 gpcd. While these values are higher than that determined by historical data, this report rationalized that future commercial and industrial developments in Erie would likely result in higher observed per capita generation rates. Therefore, in order to remain conservative, generation rates consistent with the planning criteria provided by the Denver Regional Council of Governments (DRCOG) were used to project influent annual average daily flow and maximum monthly average daily flow values for the design year 2025 and Build-out conditions.

Table 2-3. 2013 Wastewater Utility Plan – Erie NWRF Flow Projections		
Parameters	**2025**	**Buildout**
Annual Avg Flow Generation Rate (gpcd)	90	90
Max Month Flow Generation Rate (gpcd)	118	118
Flow Projections for Town of Erie North and South WRFs		
Annual Avg Daily Flow (MGD)	3.70	6.26
Max Month Flow (MGD)[a]	4.80	8.12
Peak Day Flow (MGD)[b]	6.30	10.66
Flow Projections for Town of Erie North WRF Only		
Annual Avg Daily Flow (MGD)	2.46	5.02
Max Month Flow (MGD)	3.20	6.52
Peak Hour Flow (MGD)	7.74	14.02
Peak Hour Peaking Factor for NWRF	3.14	2.79

[a] Max Month Peaking Factor for both plants = 1.3
[b] Peak Day Peaking Factor for both plants = 1.7

Future loading rates to both the NWRF and SWRF plants were calculated by multiplying the projected population values provided in Table 2-2 by the highest annual average per capita generation rates observed over the last 10 years for each parameter. The projected maximum month loading values were determined by using historically-derived maximum month peaking factors. The resultant projected loading rates to both the NWRF and SWRF are shown below in Table 2-4.

Table 2-4. 2013 Wastewater Utility Plan – Future Loads for Town of Erie from Historic Generation Rates						
Year	**BOD, ppd**		**TSS, ppd**		**NH_3-N, ppd**	
	AA[a]	**MM[b]**	**AA[a]**	**MM[b]**	**AA[a]**	**MM[b]**
2010	2,902	3,773	3,446	4,135	326	414
2015	4,244	5,517	5,040	6,048	477	606
2020	5,364	6,973	6,370	7,644	603	766
2025	6,509	8,462	7,729	9,275	732	930
2030	7,940	10,322	9,429	11,315	893	1,134
Build-out	11,011	14,314	13,076	15,691	1,239	1,574

[a] Average annual per capita generation rates: BOD = 0.16 ppdpc, TSS = 0.19 ppdpc, NH3-N = 0.018 ppdpc
[b] Maximum Month Peaking Factors: BOD = 1.30, TSS = 1.20, NH3-N = 1.27

This report estimated that the first NWRF expansion may be required prior to 2015, in order to meet the State-mandated 80% and 95% hydraulic capacity triggers, and that the second physical expansion of the NWRF would be required sometime between the years 2025 and 2030.

2.2.2 Town of Erie 2014 Project Implementation Report

The Town of Erie 2014 Project Implementation Report, developed by Frachetti Engineering, describes the basis of planning for the Erie NWRF expansion. Following the decommissioning of the SWRF in 2011, the NWRF received both wastewater influent streams, and as a result, there were periods of the year during which the plant's treatment capacity of 3,223 lb/day BOD_5 was limited or exceeded. Therefore, the goal of the NWRF expansion was to plan for increases in the plant's treatment capacity in two phases: first implement a short term capacity of 5,372 lb/day BOD_5 at 1.99 MGD, and second, a long-term capacity of 6,798 lb/day BOD_5 at 2.5 MGD. The report also stated that the projected flows and loads performed in the 2013 Wastewater Utility Plan were too conservative for the design basis of the NWRF, because the flow and loading per capita values were higher than historical data indicated. Table 2-5 shows the maximum month projected flows and loads used in this report. Total suspended solids (TSS) was not evaluated in this report and thus is not shown.

Table 2-5. 2014 Project Implementation Report - NWRF Projected Flows and Loads

Year	Max. Month Daily Flow (MGD)	Max. Month BOD (ppd)[d]	Max. Month Ammonia (ppd)[e]	Population Growth Rate
2020	1.76	4776	530	4%
2023[a]	1.98	5372	596	4%
2029[b]	2.51	6798	754	4%
2030	2.61	7069	784	4%
2035	3.17	8601	954	4%
2040	3.86	10465	1161	4%
2045	4.69	12732	1412	4%
2049[c]	5.49	14894	1652	4%
2050	5.71	15490	1718	4%

[a] Selected short term flow and loading based on paper rerating to 1.99 MGD
[b] Selected long term flow and loading based on existing secondary treatment process at NWRF
[c] Build-out calculated by 68,820 persons * 80 gpcd flow = 5.49 MGD
[d] Influent max. month BOD concentration = 325 mg/L
[e] Influent max. month NH3 concentration = 36 mg/L

A summary of all flow and loading projections completed for the short-term and long-term planning timeframes is shown below in Table 2-6.

Table 2-6. 2014 Project Implementation Report - Erie NWRF Projected Flows and Loads Summary			
Parameters	**Short-Term (2023)**	**Long-Term (2029)**	**Build-out (2049)**
Annual Avg Flow Generation Rate (gpcd)	70	70	70
Max Month Flow Generation Rate (gpcd)	80	80	80
Annual Avg Daily Flow (MGD)	1.73	2.19	4.81
Max Month Flow (MGD)	1.99	2.5	5.49
Peak Hour Peaking Factor[a]	3.33	3.20	2.81
Peak Hour Flow (MGD)	5.77	7.02	13.5
Max Month BOD (ppd)	5,372	6,798	14,894
Max Month NH3 (ppd)	596	754	1,652
WAS Production with alum sludge (ppd)	7,520	-	-
WAS Production without alum sludge (ppd)	6,016	7,614	16,681
[a] Peak hour factor based on DRCOG equation: $PF=3.65/(Q_{avg})^{0.167}$			

The remainder of the report summarizes pilot study results for testing the use of various chemicals at the NWRF to improve the solids dewatering process.

2.2.3 Town of Erie 2015 Wastewater Utility Plan Update

The Town of Erie 2015 Wastewater Utility Plan Update, written by Burns & McDonnell, provides updated population, flows, and loads projection values based on the Town of Erie 2013 Wastewater Utility Plan Update, discussed earlier in Section 2.2.1. The 2013 report original population projection values versus the updated population projections based on actual data are shown below in Table 2-7. The primary difference between the two reports is that while the 2013 report estimated 6% growth until the year 2017, the 2015 report assumed 4% population growth starting after the year 2015.

Table 2-7. 2015 Wastewater Utility Plan Updates – Updated Population Projections for the Town of Erie		
Year	**2013 WUP Population Projections**	**Updated Population Projections**
2010	18,135	18,497
2015	26,525	21,243
2020	33,525	25,845
2025	40,680	31,445
2030	49,625	38,257
2035	N/A	46,546
Build-out	68,820[a]	68,820

[a] Projected ultimate build-out population provided in the 2005 Town of Erie Comprehensive Plan

In 2011, when the SWRF was taken out of service, all of Erie's wastewater flow was sent to the NWRF. At the time of this report, the Town had no intentions to use the SWRF for wastewater treatment. Updated flows and loads projections to the NWRF were based on historical flows and loads data at the NWRF, and the updated population projections provided above. Table 2-8 below shows a summary of the 2023 design year flow and load projections, as well as the projected wastewater characteristics.

Table 2-8. 2015 Wastewater Utility Plan Updates – Design Year 2023 Flows and Loads Projections		
Parameter	**Average Day**	**Max Month**
Flow (MGD)	1.76[a]	2.01[a]
BOD (ppd)	4,361	5,233
BOD (mg/L)	257	270
TSS (ppd)	5,233	6,396
TSS (mg/L)	308	331
Ammonia as total N (ppd)	494	581
Ammonia as total N (mg/L)	29.1	30.0

[a] These influent flow values are reported differently in another section of the report. Values shown above are in Table 4-4 of the 2015 Wastewater Utility Plan, but the average day influent flow is 1.71 MGD, and the maximum month flow is 1.95 MGD in Table 4-2 of the report.

2.2.4 Preliminary Comparison of Erie Population and Flow Projections

The projection flow and load values from each report will be compared in depth to the influent flow and loading projections that HDR developed in Chapter 3. However, when comparing each report's projections for population and influent flow, note that the influent future flow values from each report is different, due to varying population growth rates, as well as varying per capita wastewater generation rates. The values for Biochemical Oxygen Demand (BOD) and ammonia influent concentrations listed tend to be on the low end of what the industry has experienced over the past 5 to 10 years.

Table 2-9. 2013 and 2015 Wastewater Utility Plan – Population and Flow Projections for the Town of Erie

Year	2013 Wastewater Utility Plan [a]	2014 Project Implementation Report [b]	2015 Wastewater Utility Plan Update [c]
Population Projections			
2010	18,135	18,497 (actual)	18,497 (actual)
2015	26,525	17,375	21,243 (actual)
2020	33,525	22,000	25,845
2025	40,680	26,750	31,445
2030	49,625	32,625	38,257
2035	--	39,625	46,546
Build-out	68,820	68,820	68,820
Maximum Month Influent Flow Projections (MGD)			
2010	2.14	1.09	1.24
2015	3.13	1.39	1.42
2020	3.96	1.76	1.73
2025	4.80	2.14	2.11
2030	5.86	2.61	2.56
2035	-	3.17	3.21
Build-out	8.12	5.49	4.61

[a] Influent flow values based on a 118 gpcd maximum month wastewater generation rate.
[b] Influent flow values based on a 80 gpcd maximum month wastewater generation rate.
[c] Influent flow values based on a 67 gpcd maximum month wastewater generation rate.

2.3 Basis for Master Plan Guiding Principles

This Master Plan contains recommendations including treatment goals, redundancy, permitting, sustainability, and safety among other topics. The primary benefits for establishing and agreeing to specific principles include:

- Documentation behind decision making with regards to liquids/solids treatment and handling.
- Provides the Town with a common understanding of the end product.
- Provides a forum for discussion, as a utility, as to where the Town should be with regards to the end product.
- Provides a framework for decision making and agreement to the final capital improvements plan.

Without defining the end goals, the following risks may be encountered:

- The Master Plan may emphasize topics that are not part of the Town's common mission or goals.
- The Town's utility staff may not be unified as a team on the end product.
- The Town is provided a Master Plan that is less cost-effective and does not meet the long term requirements.
- Consensus is not reached in a timely manner which impacts schedule completion for the Master Plan and its recommendations.

The guiding principles are summarized in . The principles were developed based the Town's mission and vision statement, and the basis for redundancy and reliability. These principles will be used to guide the Master Plan and provide a framework for evaluation of alternatives.

Table 2-10. Town of Erie Expansion Master Plan Guiding Principles and Scenarios Summary

Guiding Principle	Scenarios
• Level of Reliability	• CDPHE requires the Town's NWRF to meet average day, max month and peak hour conditions o What safety factors should be applied to the standard requirements? o How to handle annual average or annual median requirements? Always meet? Blend/average over time? o Operation during power outage o Operation during foaming event o Operation during weather event
• Level of Redundancy	• What level of redundancy should be provided to meet the reliability? • Treatment- o Number of offline treatment units while still meeting annual average, max month, peak hour? o Volume of biosolids storage- number of days? Dry or wet? o Type of biosolids storage? o Location for biosolids storage- BDCWWTF or Farm? o Backup for biosolids application to Farm? • Equipment- o Number of spare units while still meeting the annual average, max month, peak hour? • Piping and Valves- o Level of redundancy for critical areas? o Shelf spares? • Electrical and I&C- o Level of redundancy for critical areas? o Shelf spares? o Backup programming?
• Level of Odor Control	• What level of emissions is acceptable? • What distance from fence line is acceptable? • What facilities should have treatment?
• Level of Access for Operations and Maintenance	• Minimum clear distance • Tank sumps for cleaning • Cleanouts on pipes • Washdown hose bibs

Table 2-10. Town of Erie Expansion Master Plan Guiding Principles and Scenarios Summary

Guiding Principle	Scenarios
• Level of Sustainability	• Install alternative energy systems? o Solar installed in available open space? o Wind turbine? o Heat recovery system on influent sewer to provide heating for facility buildings? • Reduce energy consumption? o Reduce fuel consumption by producing the driest possible biosolids reducing truck trips for disposal. o Install centrate treatment system to significantly reduce dewatering recycle ammonia load to bioreactor system

2.4 Basis of Alternatives Evaluation

A wide range of liquid stream treatment, solids handling treatment, and biosolids management alternatives were considered for the Town of Erie. This section presents the basis applied for evaluation of alternatives developed in this report.

2.4.1 Evaluation Methodology

Alternatives were identified and evaluated through an interactive process involving Erie and HDR staff. Major elements of the process are described below.

Define Evaluation Methodology and Criteria

To provide a consistent basis of analysis, HDR and Erie staff developed a uniform evaluation methodology for the alternatives. This process defined evaluation criteria, outlined the decision-making process, and prescribed cost-estimating procedures.

Define Baseline Alternative

A critical step in the overall evaluation process is defining an accurate and comprehensive “baseline” alternative that other management concepts can be compared against. HDR developed this default scenario, which continues the current liquids and solids stream treatment and biosolids management practices at the Erie NWRF.

Brainstorm and Screen Ideas

The Erie/HDR team conducted multiple workshops to identify potential liquids/solids stream treatment processes and biosolids management alternatives for the Erie NWRF. Following the brainstorming portion of the workshop, the project team then conducted a screening step to eliminate ideas that were fatally flawed, technically unproven, excessively expensive, or otherwise unworthy of detailed evaluation.

Conduct Detail Development and Evaluation

Alternatives surviving the initial screening step were developed in detail. Facility sizing and cost estimating were then conducted for modular expansion of facility capacity for 2038 conditions. Alternatives were compared based on cost and non-economic criteria. Based on this analysis, preliminary recommendations for facility improvements could then be made.

Compare with Criteria

HDR developed capital, operating, and life-cycle costs for all final alternatives and discussed each approach relative to the non-economic evaluation criteria. Based on this discussion, the alternatives were rated against the evaluation criteria. HDR staff developed the initial ratings, and Erie staff revised the ratings later.

Decision Workshop

Based on the results of the evaluation process, the project team developed final alternatives and recommendations for consideration by Erie staff.

Develop Report

HDR prepared a report to summarize the analysis, conclusions, and recommendations.

2.4.2 Evaluation Criteria

Workshops were conducted to define the evaluation methodology and criteria. The Erie/HDR team chose a two-phase process to narrow the field of alternatives and to select the preferred management approach:

- Phase 1 – Initial Screening
- Phase 2 – Evaluation of “Short-Listed” Alternatives

Phase 1 – Initial Screening

An initial screening phase was developed to eliminate alternatives that are fatally flawed or clearly unattractive compared to other remaining alternatives. This phase reduced the number of system-wide alternatives to a manageable number.

Phase 2 – Evaluation of Short Listed Alternatives

Decision Support Method

For evaluation of the short-listed alternatives, the project team chose a decision support method that allows a comparison of life-cycle costs against “non-cost” benefits. This method includes the following steps:

- Select evaluation criteria representing important non-monetary benefits or attributes of an alternative that are independent, provide differentiation, and can be objectively assessed.
- Weight each decision criteria to prioritize the importance of the benefit or attribute to the decision process.
- Develop a scoring methodology to define the performance of each alternative with respect to each evaluation criteria.
- Score the alternatives.
- Calculate the non-monetary benefits offered by each alternative.
- Develop life-cycle cost estimates for each alternative.
- Calculate the benefit-to-cost ratio for each alternative.
- Discuss the decision process results and the value of benefits relative to the additional costs or savings afforded to select the best alternative.

Evaluation Criteria and Weighting

lists a number of the evaluation criteria the Erie/HDR team selected and applied.

Table 2-11. Non-Economic Evaluation Criteria	
Non-Economic Criteria	**Benefits or Attributes**
Operator Attention	• Technology is self-sufficient • Low operator need to check the equipment
Operator Familiarity	• How familiar is staff with the technology? • How comfortable is the staff with operation of this technology? • How comfortable is the staff with operation the equipment unattended overnight?
Maintenance Requirements/Complexity	• How often must the equipment be maintained? • How difficult is the equipment to maintain? • How much downtime will the system need to be maintained on a yearly basis?
Long-Term Viability	• Is equipped to handle expansion • System operates effectively over a wide variety of conditions • Has ability to withstand or adjust to regulatory changes • Has ability to withstand or adjust to changes in public perception (e.g., health concerns, aesthetics, urban/rural issues, etc.) • Has ability to remain cost effective if energy or labor costs change significantly • Has ability to reuse or dispose of product on a long-term basis (strong market, diverse products and end use options, acceptable level of competition)
Footprint	• Low amount of operational space needed for O&M • Low amount of overall space required
Technology	• Technology has been successfully implemented at other facilities with similar capacities • Compatible with the site (adequate space available, including storage needs) • Impacts on liquid treatment capacity and performance are acceptable and can be mitigated • Acceptable reliability and redundancy • Robustness of the technology • Acceptable impacts on staffing (number of staff, training, hours of operation)
Environmental Stewardship	• Provides beneficial use of resources • Has minimal impact on local environment • Does not adversely affect hydrology, biological resources, etc.

Table 2-11. Non-Economic Evaluation Criteria	
Non-Economic Criteria	**Benefits or Attributes**
Community Impacts	• Acceptable noise generation (based on off-site detection) • Acceptable odor generation (based on off-site detection) • Acceptable dust generation (based on off-site detection) • Minimizes traffic impacts to local streets and freeways • Does not adversely affect public safety • Does not adversely affect public health • Acceptable aesthetics
Implementability	• Permits and approvals are obtainable • Can negotiate necessary public or private partnership agreements • Can implement project within the required timeframe • Implementation will result in low overall operation and maintenance costs
Redundancy	• Maintains or increases the Town's autonomy • Avoids the potential for long-term commitments that may not be beneficial to Erie • Feasibility to take a piece of equipment offline

Criteria weighting was determined through a forced ranking procedure in which the project team directly compared each criterion against each of the "competing" criterion. The results were recorded, and a summary weighting was developed.

2.5 Cost Estimating Methodology

An opinion of probable costs has been prepared for the final developed alternatives. The American Association of Cost Engineers has defined three basic categories of estimates in an effort to establish an expected accuracy range for various types of cost estimates. They include:

- Order of Magnitude Estimate – This is an approximate estimate made without detailed engineering data. Some examples would be: an estimate from cost-estimating curves, an estimate using scale-up or scale-down factors, or an approximate ratio estimate. It is normally expected that an estimate of this type would be accurate within +50 percent or -30 percent.
- Budget Estimate – The term budget in this case applies to the owner's budget and not the budget as a project-control document. A budget estimate is prepared with the use of spreadsheets, layouts and equipment details. It is normally expected that an estimate of this type would be accurate within +30 percent or -15 percent.
- Definitive Estimate – As the name implies, this is an estimate prepared from well-defined engineering data. At a minimum, the data must include: fairly complete plans and elevations, piping diagrams, equipment data sheets and quotations, structural sketches, soil data and a complete set of specifications. The "maximum" definitive estimate would be made from Approved for Construction" drawings and

specifications. It is expected that a definitive estimate would be accurate within +15 percent or -5 percent.

Based on the current level of this project's development and engineering efforts, and considering that no subsurface (geotechnical) investigations have been performed, an order of magnitude estimate is the most accurate description of the probable project costs that can be expected. As site specific information is obtained and designs are refined, a more accurate cost opinion can be developed. The primary objective of the cost opinions presented in the plan is to provide a basis for comparison of relative costs between alternatives.

Capital costs are expressed in 2018 dollars. The accuracy of all costs is order of magnitude. These estimates are approximations made without detailed engineering or site-specific data. Estimates of this type can be expected to vary from 50 percent less than to 30 percent more than actual final project costs.

The sources of construction cost data are:

- Construction cost data for the recent Colorado Front Range area projects and recent HDR designed projects, adjusted to 2018 dollars.
- Recent construction costs for other, similar facilities, adjusted to regional market conditions and 2018 dollars.
- Equipment pricing from manufacturers, including installation and structure costs.

2.5.1 Capital Costs

All capital costs include allowances for sitework and yard piping; contractor mark-up; contingencies; and engineering, legal and administration costs. The cost estimating procedure is presented in . Appendix A contains the detailed cost estimates.

Table 2-12. Illustration of Capital Cost Estimating Procedure

Cost Item
Base Construction Cost
Electrical and Controls (% of Base Construction Cost)
Total Direct Costs Subtotal
Estimating Contingency for Items Not Specifically Itemized (30% of Total Direct Costs Subtotal)
General Contractor Overhead, Profit & Risk (15% of Total Direct Costs Subtotal + Estimating Contingency)
Escalation to Mid-Point of Construction (4% per year)
Bid Market Allowance (5% of Total Direct Cost Subtotal + Estimating Contingency + General Contractor Overhead, Profit & Risk + Escalation to Mid-Point)
Total Estimated Construction Cost Subtotal
Engineering, Legal, Administration (25% of Total Estimated Construction Cost Subtotal)
ROW/Land Acquisition
Permits/Fees

Table 2-12. Illustration of Capital Cost Estimating Procedure
Cost Item
Subtotal
Town Project Contingency - City Reserve for Change Orders (10% of Subtotal)
Total Anticipated Project Cost (TAPC)

2.5.2 Inflation and Discount Rate

HDR calculated the 10-year net present value for the alternative to keep existing equipment and systems as they currently are, and for the ATAD system alternative. Future costs are inflated at a rate of 2.2 percent. The nominal interest rate of 2.1 percent for a 10-year time period was used as published by the Executive Office of the President, 2017. Net present values were calculated using 2017 as the base year and extending into 2028.

2.5.3 Operating Costs

HDR developed current operating costs for the following categories:

- Labor
- Energy
- Chemicals

Labor

HDR used a flat hourly rate of $32/hr for the estimation of labor.

Energy

HDR calculated power costs using motor horsepower, voltage, drive type, power demand, and hours of service for expected equipment. For electrical power, a unit cost of $0.08/kW-hr was used for both electricity consumed and electricity produced by any on-site power generation facilities. It is understood the NWRF utility bill includes demand charges, peaking charges and other surcharges. For the sake of simplification, the average unit cost of $0.08/kW-hr was applied to all power cost calculations.

For natural gas, a unit price of $6.05 per million BTU (MMBTU) was used.

Chemicals

lists current unit costs for chemicals included in the cost estimates. HDR developed costs for chemicals consumed by the solids processing facilities.

Table 2-13. Chemical Cost Breakdown	
Chemical	**Unit Cost**
Polymer	$1.75/active lb
Lime	$0.13/lb
Ferric Sulfate	$0.12/lb

Contents

3 Wastewater Characterization 3-1

3.1 Introduction 3-1

3.2 Land Use and Wastewater Service Area 3-1

3.3 Population Projections 3-3

3.3.1 Population Growth Comparison 3-5

3.3.2 Recommended Population Growth Rate 3-6

3.3.3 Build-out Population Expansion 3-7

3.4 Analysis of Historical Liquids Stream Flows and Loads 3-8

3.4.1 Per Capita Wastewater Generation and Loading Rates 3-9

3.5 Projected Liquids Stream Flows and Loads 3-10

3.6 Analysis of Historical Solids Stream Flows 3-11

3.6.1 Yield Values for Produced Biosolids 3-11

3.7 Projected Solids Stream Flows 3-12

3.7.1 Solids Stream Projections with Secondary Treatment Expansions 3-13

3.8 Previous Planning Studies Comparison 3-14

3.9 Recommended Liquids and Solids Projections Summary 3-16

Tables

Table 3-1. Historical Population Growth Rate 3-4

Table 3-2. Recommended Population Projection Summary 3-7

Table 3-3. Historical Influent Flows and Loads Data 3-8

Table 3-4. Per Capita Influent Flows and Loads Summary 3-9

Table 3-5. Projected Influent Flows and Loads Data 3-10

Table 3-6. Historical Solids Flows at the Erie NWRF 3-11

Table 3-7. Yield Values for Projecting Biosolids Flows 3-12

Table 3-8. Projected Solids Flows at the Erie NWRF 3-12

Table 3-9. Projected Solids Flows at the Erie NWRF with Secondary Treatment Expansion 3-13

Table 3-10. Previous Reports Comparison – Population and Flow Projections for the Town of Erie 3-14

Table 3-11. Previous Reports Comparison of Influent Loading Parameters: BOD, TSS, and Ammonia 3-16

Table 3-12. Summary of Recommended 10 and 20 Year Design Values 3-17

Figures

Figure 3-1: Town of Erie Land Use Map (Provided by 2015 Comprehensive Plan) 3-2

Figure 3-2: Town of Erie Planning Area Boundary 3-3

Figure 3-3: 2015 WUP Projection versus Historical Data 3-4

Figure 3-4: Comparison of Population Projections with Various Growth Rates 3-6

Figure 3-5: Recommended Population Projection for the Town of Erie 3-7

This page is intentionally left blank.

3 Wastewater Characterization

3.1 Introduction

The purpose of this chapter is to develop and provide the following:

- Current and future wastewater service area
- Current and future land use and population projections
- Current and future wastewater flows and loads

Average, maximum month, and peak hour flows and loads were projected for the next 20 years to provide the framework for an expected schedule of expansion improvements at the Town of Erie's North Water Reclamation Facility (NWRF).

3.2 Land Use and Wastewater Service Area

The Town of Erie's 2015 Comprehensive Plan established policies and goals regarding land use within the Town's Planning Area. It also provided a land use map, Figure 1, which designated certain areas for various uses. The Town's Planning Area Boundary is designated by the bold black line. The Planning Area Boundary is defined in the 2015 Comprehensive Plan as areas in which Erie would like to influence land use decisions. However, not all of the area within the Town's Planning Area Boundary may be formally incorporated into the Town's boundary. The Town's Planning Area Boundary map, which was provided in the 2015 Comprehensive Plan, is shown in Figure 2.

The Town's NWRF falls under the "Public/Quasi-Public" land use category, which is represented by the light blue colored areas in the land use map.

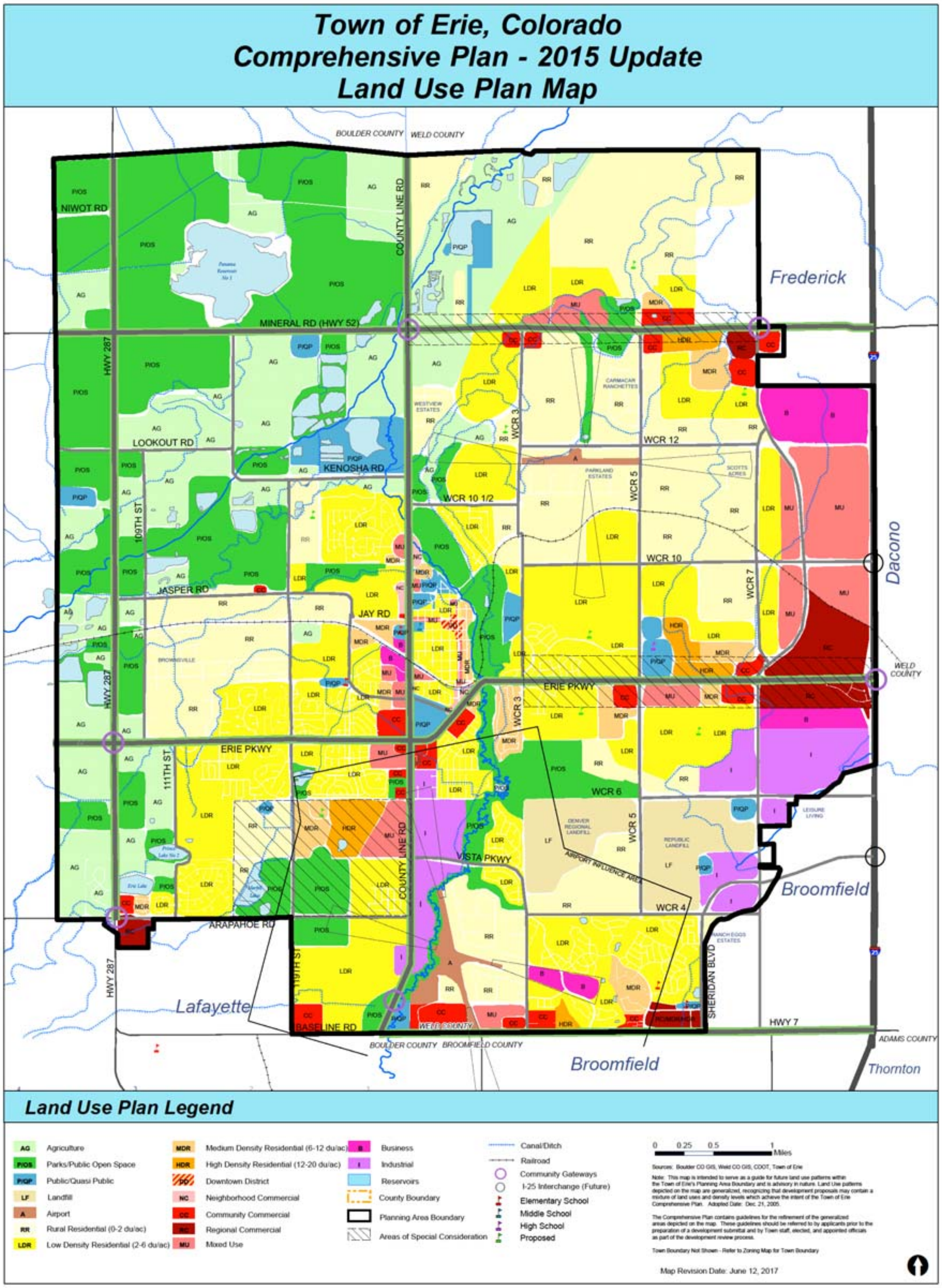


Figure 3-1: Town of Erie Land Use Map (Provided by 2015 Comprehensive Plan)

At the June 2018 board meeting, the Town explained that they are considering expanding the town boundaries in the near future, incorporating more development possibilities. This would increase the build-out population value presented in previous utility plans. While this report does not incorporate the potential boundary expansion, this should be evaluated in the next wastewater utility plan.

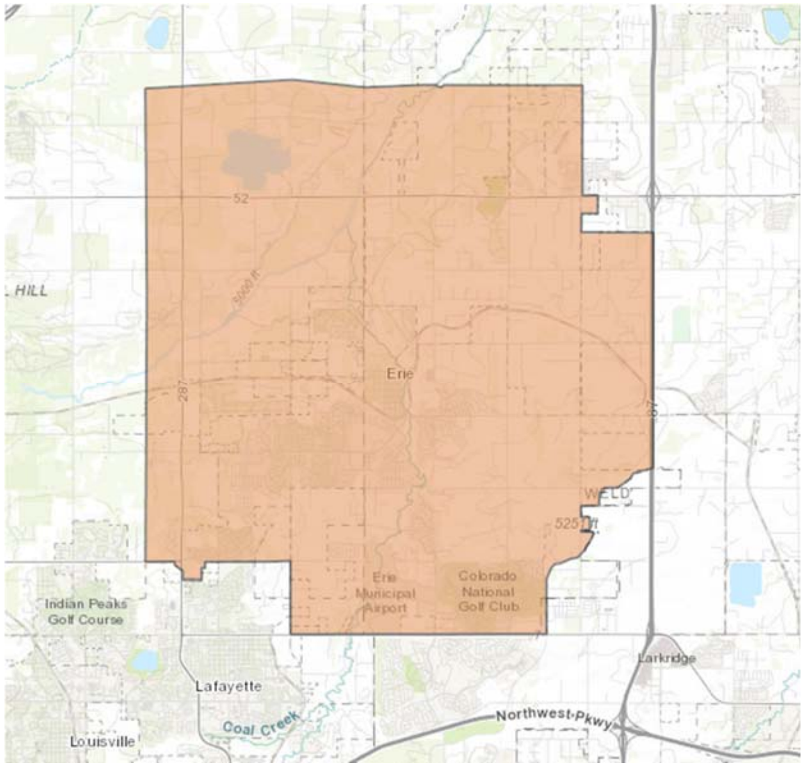


Figure 3-2: Town of Erie Planning Area Boundary

3.3 Population Projections

Originally, HDR intended to use population projections provided in the 2015 Wastewater Utility Plan (WUP) Update report, which are summarized in Chapter 2. However, since that report, the Town of Erie has been experiencing more rapid growth that predicted in the 2015 WUP. The 2015 WUP used 4% growth beyond the year 2015. Figure 3 below displays historical population data compared to the 2015 WUP projections, as well as an updated population projection with 4% population growth. For the updated population projection, actual populations for 2016 and 2017 were added to the data, and a 4% growth each year was used from the 2017 population number to update the 2015 projected population numbers.

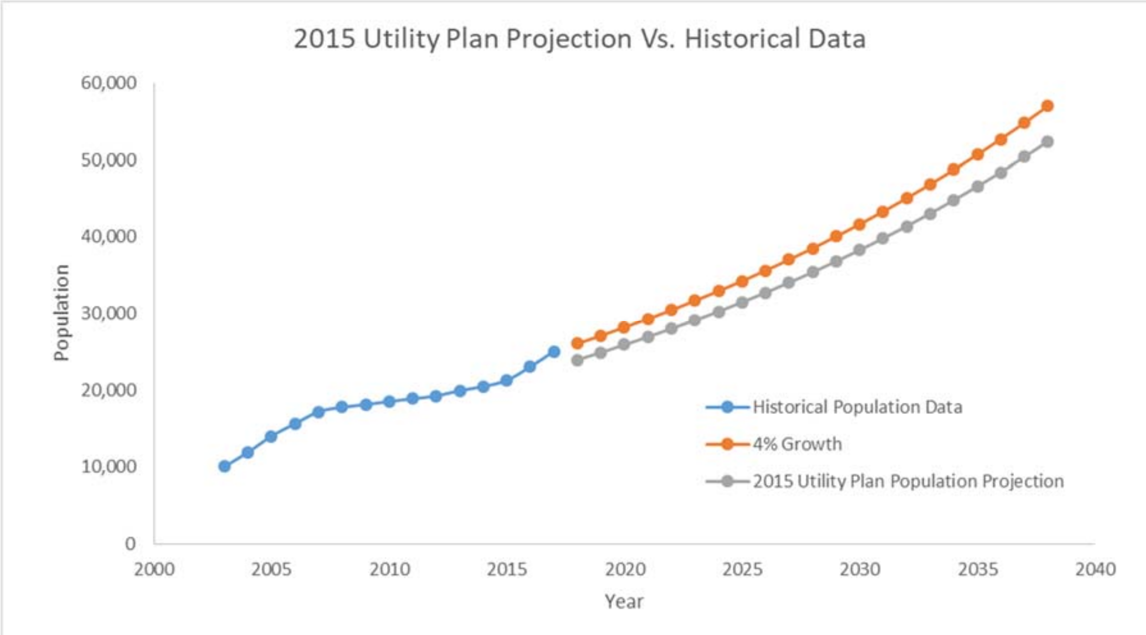


Figure 3-3: 2015 WUP Projection versus Historical Data

As shown in the figure, current population data already exceeds future population estimates provided in the 2015 WUP, indicating that the previous population projections are based on too slow of a growth rate. In order to ensure that the expansion planning provided in this report is based on a more accurate population projection, HDR updated the population projections by analyzing historical growth rates in Erie over the past 15 years. Table 3-1 below provides historical population growth rates observed in Erie since 2003.

Table 3-1. Historical Population Growth Rate

Year	Historical Population Data	Yearly Percent Growth
2003	10,041	
2004	11,908	18.6%
2005	13,996	17.5%
2006	15,610	11.5%
2007	17,164	10.0%
2008	17,750	3.4%
2009	18,088	1.9%
2010	18,497	2.3%
2011	18,855	1.9%

2012	19,215	1.9%
2013	19,915	3.6%
2014	20,431	2.6%
2015	21,243	4.0%
2016	23,031	8.3%
2017	25,000	8.5%
	Average	**6.9%**

From 2003 to 2007, high population growth rates from 10% - 18.9% were observed in Erie. From 2008 to 2015, which included the recession, the growth rate dropped to 1.9% - 4%. Since 2016, the growth rate has risen again to approximately 8.5%, which is consistent with US economic status data.

3.3.1 Population Growth Comparison

A comparison of several population projections using various exponential population growth rates is shown in Figure 4. As shown in this figure, for a population growth rate of 6%, 6.9%, and 8%, the projections predict that the Town reaches Build-out conditions in 2034, 2032, and 2029, respectively. If a 4% growth rate is used, the projections show that Build-out conditions are not reached within the next twenty years. However, more recent population data indicates that the population in Erie is growing at a rate faster than 4%. Therefore, it is anticipated that approximately 8% growth will occur for the next five or so years, consistent with the last couple years in Erie.

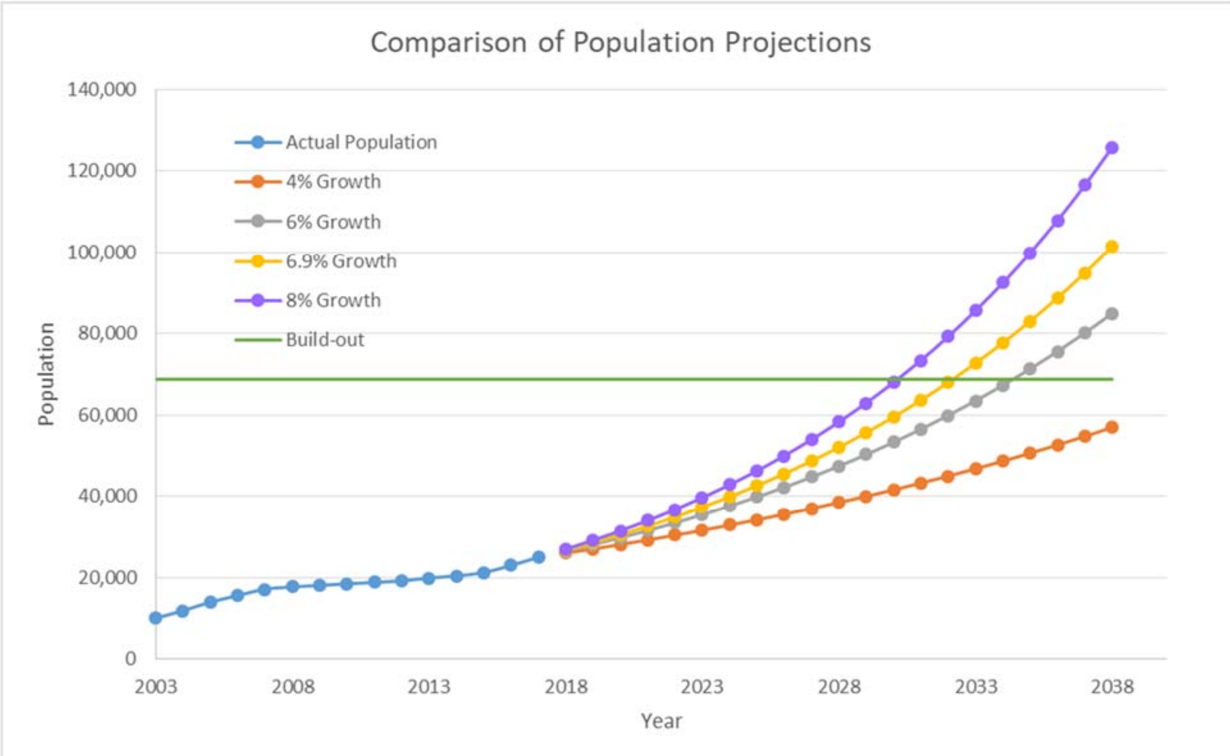


Figure 3-4: Comparison of Population Projections with Various Growth Rates

3.3.2 Recommended Population Growth Rate

Figure 5 below shows population projections for exponential growth rates of 4%, 6%, and 8% for five years, then 5% afterwards. These exponential growth patterns are also compared to a linear growth rate of 8% for five years, and 5% afterwards. Based on input from the Town of Erie, the recommended population projection rate is based on an 8% exponential growth rate until 2022, and then 5% exponential growth rate from 2023 and on. This projection method allows for conservative planning for the next five years, based on trends observed in recent years, but also prevents overestimating population growth in twenty years. The Town's Build-out conditions in the recommended projection, as shown in the figure below, are reached close to when they would be reached for a 6% growth rate, which is close to the average growth rate seen in Erie since 2003. Therefore, the recommended population projection is best able to provide required conservancy for near future conditions, and also capture average historical growth rates for long term conditions.

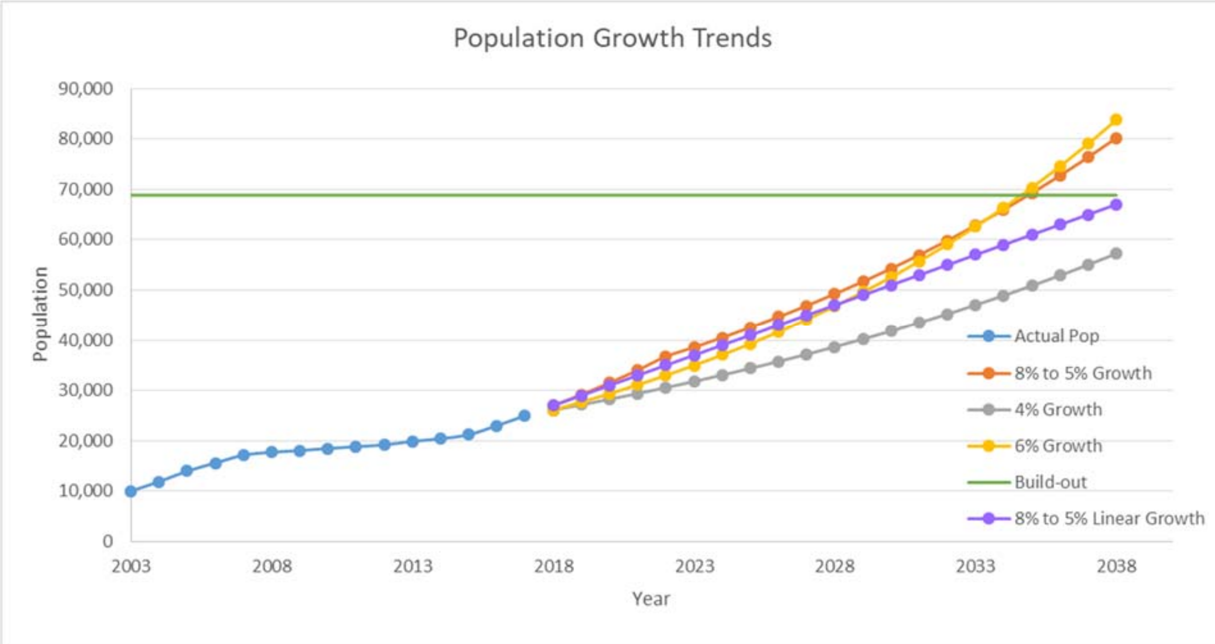


Figure 3-5: Recommended Population Projection for the Town of Erie

Table 3-2 below provides a summary of the projected population values that are used as a basis of planning throughout the rest of this Master Plan for a number of years.

Table 3-2. Recommended Population Projection Summary		
Year	Population Value	Yearly Percent Growth
2020	31,493	8%
2025	42,523	5%
2028	49,226	5%
2030	54,272	5%
2035	69,266	5%
2038	80,184	5%
Build-out (2034)	68,820	5%

3.3.3 Build-out Population Expansion

As shown in Table 3-2, Build-out population is reached before the end of the twenty year planning window that is used throughout this Master Plan. However, as mentioned earlier, the Town is currently evaluating expanding the town limits for development, which may increase the Build-out population conditions. Therefore, in order to provide a conservative planning basis, the NWRF influent flows and loads projections and the

NWRF solids flow projections provided later in this chapter assume that Erie will expand its Town boundaries to accommodate a population higher than its current Build-out population. However, these population projections should be re-evaluated if and when additional development areas are allotted for Erie, and added into the NWRF's wastewater service area.

3.4 Analysis of Historical Liquids Stream Flows and Loads

The Town of Erie provided HDR with historical influent data for 2016 and 2017. The average day and maximum month values for influent flow, biochemical oxygen demand (BOD), total suspended solids (TSS), ammonia loading, and phosphorus loading are shown below in Table 3-3.

Table 3-3. Historical Influent Flows and Loads Data

Historical Flow Values		
Year	**2016**	**2017**
Avg Day Influent Flow (MGD)	1.30	1.43
Max Month Influent Flow (MGD)	1.38	1.58
Historical Loading Values[a]		
Avg Day BOD (mg/L / lb/d)	301 / 3,256	299 / 3,568
Max Month BOD (mg/L / lb/d)	371 / 4,261	372 / 4,893
Avg Day TSS (mg/L / lb/d)	323 / 3,494	294 / 3,509
Max Month TSS (mg/L / lb/d)	436 / 5,007	336 / 4,419
Avg Day Ammonia (mg/L / lb/d)	36 / 389	36 / 430
Max Month Ammonia (mg/L / lb/d)	39 / 448	49 / 644
Avg Day Phosphorus (mg/L / lb/d)	19 / 206	19 / 227
Max Month Phosphorus (mg/L / lb/d)	25 / 287	24 / 316

[a] Concentration values (mg/L) are historical data provided by the Town of Erie. Loading values (lb/d) are calculated from the concentration values and influent flow:
Load (lb/day) = 8.34 (lb*L/(MG*mg)) * Flow (MGD) * Concentration (mg/L)

All influent loading parameters were calculated by converting the average day or maximum month concentrations into loading values in pounds per day. In order to capture the most conservative maximum month loading scenarios that could be seen at the Erie NWRF, the maximum month influent concentrations were multiplied by the maximum month flow, and then converted into pounds per day.

Note that in 2017 the maximum month influent flow was 1.58 MGD, which is 80 percent of the plant's rated capacity. Per CDPHE Regulation 61.8(7), maximum month flows reaching 80 percent of the facility's permitted capacity triggers the requirement to begin planning efforts for a plant expansion. When maximum month flows reach 95 percent of the facility's rated capacity, the facility is required to begin construction of plant expansion. According to the projected flows provided in section 3.5, the Erie NWRF reaches the 95 percent trigger of 1.85 MGD between 2019 and 2020.

3.4.1 Per Capita Wastewater Generation and Loading Rates

In order to project each of the influent parameters shown in Table 3-3 above, each historical parameter value for 2016 or 2017 was divided by the population value for its respective year, and those values were averaged to find a per capita wastewater generation or loading rate. The average day and maximum month per capita wastewater generation and loading rates are summarized below in Table 3-4.

Table 3-4. Per Capita Influent Flows and Loads Summary

Parameter	Average Day Per Capita Value	Maximum Month Per Capita Value
Influent Flow (gal/day/cap)	56.8	61.5
Influent BOD (lb/d/cap)	0.1421	0.1905
Influent TSS (lb/d/cap)	0.1461	0.1972
Influent Ammonia (lb/d/cap)	0.0171	0.0226
Influent Phosphorus (lb/d/cap)	0.0090	0.0126

All influent liquids streams flow and load projections that follow are based on the per capita wastewater generation and loading rates shown above. As mentioned in Chapter 2, the 2013 Wastewater Utility Plan used an average day and maximum month per capita wastewater generation rate of 90 gpcd and 118 gpcd, respectively. However, these values are very high when compared to the US average of 50 to 70 gpcd, as reported by USEPA. The 2014 Project Implementation Report used values of 70 gpcd and 80 gpcd for average day and maximum month wastewater generation rates. These values are also higher than the US average. Lastly, the 2015 WUP used wastewater generation rates of 58.8 and 67 gpcd. These values are more consistent with national averages; however, as discussed in Section 3.4, a 4% population growth rate may still result in too low of NWRF influent flows, due to a faster growing population in Erie.

Another discrepancy between the per capita loading rates developed by HDR and those from previous reports is the BOD concentration. Previous reports use values that are on the low end of what the industry has observed in the past decade. The 2016/2017 average and maximum month influent BOD wastewater concentration were 301 mgBOD5/L and 371 mg/L respectively, which is consistent with BOD concentrations seen in other Colorado wastewater treatment plant influent.

3.5 Projected Liquids Stream Flows and Loads

After the average day and maximum month per capita wastewater flows and loading rates were determined for each parameter, projected flows and loads were calculated for the next 20 years. Using the population projection shown in Section 3.4.3, which used an 8% growth rate until 2022, and a 5% growth rate for year 2023 and after, each per capita rate was multiplied by each year's population value, to determine influent flows and loads to the NWRF for each year. A summary of the projected flows and loads for the ten year design conditions and twenty year design conditions are shown below in Table 3-5.

Table 3-5. Projected Influent Flows and Loads Data

Year	2028	2038
Projected Population	49,226	80,184
Avg Day Influent Flow (MGD)	2.80	4.56
Max Month Influent Flow (MGD)	3.03	4.93
Avg Day BOD (lb/d)	6,997	11,398
Max Month BOD (lb/d)	9,376	15,273
Avg Day TSS (lb/d)	7,193	11,717
Max Month TSS (lb/d)	9,709	15,815
Avg Day Ammonia (lb/d)	840	1,368
Max Month Ammonia (lb/d)	1,114	1,814
Avg Day Phosphorus (lb/d)	443	722
Max Month Phosphorus (lb/d)	618	1,007

The influent flow projections show that NWRF expansions for 2028 should bring the plant's firm capacity from its current capacity of 1.95 MGD to approximately 3 MGD, and 2038 plant expansions should bring the capacity to about 5 MGD. As shown, the average day and maximum month projection values are not significantly different; this is due to a lower volume of inflow and infiltration, which is likely due to the high volume of new piping that is currently being installed in the Town of Erie to meet its rapidly growing population. Chapter 5 provides an in-depth analyses of the liquids treatment stream expansions necessary to meet these projected capacities.

3.6 Analysis of Historical Solids Stream Flows

The Town of Erie also provided historical solids flow data for 2016 and 2017 at the NWRF, which are summarized below in Table 3-6. The existing solids treatment process at the Erie NWRF uses lime solids stabilization. Waste activated sludge (WAS) from the integrated fixed film activated sludge (IFAS) treatment process is sent to the WAS storage tanks, and then to the lime mixing tanks, where sludge is mixed with hydrated lime for stabilization. After mixing with lime, sludge is sent to the plant's FKC rotary screen thickener for thickening, and then directly to the dewatering screw press, where the steam and dewatering process further stabilize solids for a Class A biosolids end product. An in-depth analysis of the plant's solids treatment process is further described in Chapter 6.

Table 3-6. Historical Solids Flows at the Erie NWRF

Parameter	2016	2017
Maximum Month Return Solids Flow (RAS) (gal/day)[a]	1,344,655	1,003,613
Maximum Month Return Solids Flow (RAS) (lb/day)[b]	147,882	118,272
Maximum Month Waste Solids Flow (WAS) (gal/day)[a]	56,355	48,419
Maximum Month Waste Solids Flow (WAS) (lb/day)[b]	6,198	5,706
Maximum Month Dewatered Solids (lb/day)[c]	7,398	6,906

[a] Value is based on actual data provided by the Town.
[b] Calculated by converting RAS or WAS flow in gal/day to lb/day using average of historical percent total solids data. Note that %TS was only provided for RAS stream, so %TS was assumed to be the same for both WAS and RAS.
[c] Calculated by adding average lime use provided by Town (0.6 tons/day) to WAS solids (in lb/day)

3.6.1 Yield Values for Produced Biosolids

Yield values were projected via a method similar to projecting the liquids stream flows. However, rather than calculating a flow per capita value for each parameter, each parameter was divided by the influent BOD in pounds per day, since there is a correlation between influent BOD and produced biosolids. However, the correlation between influent BOD and produced biosolids is less direct than the correlation between influent flows and loads and population. There are a number of in-plant factors that affect the biosolids produced, and the Erie NWRF has the capacity to hold solids or push treatment regardless of the influent BOD. Therefore, rather than using two different yield values for average day and maximum month, the historical average day RAS and WAS flows in pounds per day were divided by the average day influent BOD in pounds per day, and that yield value was used to project both average day and maximum month values for RAS and WAS.

The yield values used for RAS and WAS are shown below in Table 3-7.

Table 3-7. Yield Values for Projecting Biosolids Flows	
Parameter	**Average Yield Value (lb solids/lb influent BOD)**
Recycled Activated Sludge	28.4
Waste Activated Sludge	1.3

The dewatered solids were projected by adding an average daily lime use to the WAS projected flows, since all WAS fed to the rotary screen thickener is sent directly to the dewatering screw press without undergoing any form of digestion. Current lime usage shows that lime and WAS biosolids are added in a 1:5 ratio of pounds of lime to pounds of WAS biosolids. This ratio remained the same throughout the dewatered solids projections.

3.7 Projected Solids Stream Flows

Similar to the liquids stream flow projections, the yield values provided in Section 3.7.1 were used to project solids stream flows based on an 8% growth rate until 2022, and a 5% growth rate for year 2023 and after. For each solids stream flow, the corresponding yield value was multiplied by the average day or maximum month influent BOD value to find the resultant expected solids volume produced. The WAS or RAS value was converted from pounds per day to gallons per day using the average percent total solids concentration, which was based on historical data provided by the Town. Essentially, all maximum month solids stream projections were based on average day total solids concentrations and average day BOD to biosolids yield values, but were projected with maximum month influent BOD loadings.

Table 3-8 below summarizes projected solids stream flows for design years 2028 and 2038.

Table 3-8. Projected Solids Flows at the Erie NWRF		
Parameter	**2028**	**2038**
Maximum Month Return Solids Flow (RAS) (MGD)	2.34	3.81
Maximum Month Return Solids Flow (RAS) (lb/day) [a]	266,387	433,917
Maximum Month Waste Solids Flow (WAS) (gal/day)	107,005	174,301
Maximum Month Waste Solids Flow (WAS) (lb/day) [a]	12,189	19,855

Table 3-8. Projected Solids Flows at the Erie NWRF		
Parameter	2028	2038
Maximum Month Dewatered Solids (lb/day) [b]	14,627	23,826
[a] Assumes approximately 1.37% total solids. [b] Assumes 1 lb lime per 5 lbs WAS		

These projections assume a base case scenario: no digestion is implemented within the next twenty years, no alum sludge is accepted to the NWRF from the water treatment plant, the NWRF continues to use lime for biosolids stabilization, and that the lime usage remains proportionally the same until 2038. As mentioned above, current lime usage in pounds per day equals approximately 20 percent by weight of WAS biosolids. Projections for the next twenty years continue to assume that lime usage for stabilization is equal to 20 percent of WAS biosolids.

3.7.1 Solids Stream Projections with Secondary Treatment Expansions

As mentioned briefly in Section 3.6, liquids stream expansions are necessary to meet projected future capacities. The required expansions are described in detail in Chapter 5. However, in order to predict the effect of liquids stream expansions on the projected solids streams, HDR reached out to the manufacturer of the NWRF's secondary IFAS treatment system, Veolia Water Tech, formerly known as Kruger. They provided an estimate of the expected maximum month WAS and RAS flows after IFAS expansion. A summary of the projected solids stream flows provided by Kruger is provided below in Table 3-9.

Table 3-9. Projected Solids Flows at the Erie NWRF with Secondary Treatment Expansion		
Parameter	2028	2038
Maximum Month Return Solids Flow (RAS) (MGD)	3.03	4.93
Maximum Month Return Solids Flow (RAS) (lb/day)	346,202	563,291
Maximum Month Waste Solids Flow (WAS) (gal/day)	102,711	160,650
Maximum Month Waste Solids Flow (WAS) (lb/day)	11,700	18,300

The RAS flow projections assume that the RAS rate is 100% of influent flow, in order to be conservative. The actual RAS rate may be anywhere from 50% to 100% of the influent flow, which may explain the discrepancy between the values shown above in Table 3-8 and those shown in Table 3-9. The WAS flow values provided by Kruger, however, are comparable to the calculated projected values provided in Table 3-8, which helps to verify the accuracy of those projections. Since the WAS flow values provided by Kruger are based on modelling, and account for secondary treatment expansions that will be necessary to the NWRF in the next phase of improvements, the values shown above in Table 3-9 are the recommended values that will be used as a basis for the solids treatment process analysis discussed further in Chapter 6.

3.8 Previous Planning Studies Comparison

As stated previously in Chapter 2, it is important to examine previous studies and compare their projected design flows and loads to those developed by HDR. Projected design values affect the schedule and feasibility of the recommended expansion plans so there should be defensible reasoning that explains why any discrepancies exist, in order to ensure that the basis of planning values are valid. A summary of population and influent flow projections for a number of years from each study is provided below in Table 3-10.

Table 3-10. Previous Reports Comparison – Population and Flow Projections for the Town of Erie

Year	2013 Wastewater Utility Plan [a]	2014 Project Implementation Report [b]	2015 Wastewater Utility Plan Update [c]	HDR Projections [d]
Population Projections				
2010	18,135	18,497 (actual)	18,497 (actual)	18,497 (actual)
2015	26,525	17,375	21,243 (actual)	21,243 (actual)
2020	33,525	22,000	25,845	31,493
2025	40,680	26,750	31,445	42,523
2030	49,625	32,625	38,257	54,272
2035	--	39,625	46,546	69,266
Build-out	68,820	68,820	68,820	68,820
Maximum Month Influent Flow Projections (MGD)				
2010	2.14	1.09	1.24	-
2015	3.13	1.39	1.42	-
2020	3.96	1.76	1.73	1.94
2025	4.80	2.14	2.11	2.61
2030	5.86	2.61	2.56	3.34
2035	-	3.17	3.21	4.26
Build-out	8.12	5.49	4.61	4.23

[a] Influent flow values based on a 118 gpcd maximum month wastewater generation rate.
[b] Influent flow values based on a 80 gpcd maximum month wastewater generation rate.
[c] Influent flow values based on a 67 gpcd maximum month wastewater generation rate.
[d] Influent flow values based on a 61.5 gpcd maximum month wastewater generation rate.

A number of observations can be drawn from this comparison:

- Population projection values provided by previous reports were typically lower than those provided by HDR. However, as discussed in Section 3.3, when compared to current population data, previous population projections proved to be too low. Erie has been growing at a rate faster than originally anticipated, which triggered the need for updated population projections. Based on input from the Town, HDR's updated population projection was based on current population data, and uses a growth rate of 8% for the first five years, and 5% growth from 2023 to 2038.
- For influent flows, the values from the 2013 WUP were much higher than HDR's values, despite the population values being generally lower. This is most likely due to the high wastewater generation rate per capita of 118 gpcd used in this report. This value significantly exceeds any industry standards or national averages, yielding projected influent flows that are likely too conservative.
- Influent flow rate projections provided in the 2014 Project Implementation Report and 2015 WUP Update are more comparable to those provided by HDR, because these reports used wastewater generation rates per capita that are more consistent with industry standards.
- The influent flow projections provided by HDR are slightly higher than the other values because HDR's population projections predict higher population values, due to the corrected growth rates applied (8% until 2022, and 5% from 2023 to 2038).
- HDR's projected Build-out influent flow value is lower than all the other reports; however, this is because HDR's population projections calculate Build-out conditions prior to 2035, whereas other reports predict Build-out conditions after 2035.

In order to verify the validity of the projected influent loading values determined, Table 3-11 was developed to provide a direct comparison with the projections from the previous planning studies. All parameters used their respective 2023 value, including this Master Plan, in order to provide a direct comparison between the various studies. Since the 2013 WUP did not provide values for 2023, and it was updated with the 2015 WUP, that study was omitted from this comparison. Note that none of the previous report provided influent loading projections for phosphorus, and therefore it is not included in this comparison.

Table 3-11. Previous Reports Comparison of Influent Loading Parameters: BOD, TSS, and Ammonia

Parameter	2014 Project Report (2023 Projection)	2015 WUP (2023 Projection)	2018 HDR Recommendation (2023 Projection)
	Max Month	Max Month	Max Month
Flow (MGD)	1.98	2.01	2.37
BOD (lb/d)	5,382	5,233	7,347
BOD (mg/L)	325	270	372
TSS (lb/d)	-	6,396	7,607
TSS (mg/L)	-	331	386
Ammonia, total N (lb/d)	596	581	873
Ammonia, total N (mg/L)	36	30.0	44

Across all parameters, HDR's projected influent loading values are higher than those provided in previous reports. However, this is due to the higher influent flow projections discussed earlier, as well as using parameter concentrations that were reflective both of the Erie NWRF's historical data, as well as what is typically observed in Colorado wastewater influent.

Since none of the previous reports incorporated solids flow projections, a comparison of solids flow projections is not provided. However, a description of the NWRF solids treatment capacity analysis as it relates to projected solids flows is provided in Chapter 6, and a comparison of HDR's recommendations and findings is compared to the capacity evaluations provided in previous reports as well.

3.9 Recommended Liquids and Solids Projections Summary

Table 3-12 summarizes the design year (2028 and 2038) influent flows and loads that will be used as the overall basis for design. These values impact equipment sizing, as well as downstream processes as determined by the solids mass balance. These values serve as sizing criteria and will determine the required capacity for each design task in this Master Plan.

These values are based on a compounded 8 percent growth for five years dropping to 5 percent growth thereafter projection method. This projection method results in values that lie conservatively within the low and high ends of the other projection methods, and also is the best representation of expected growth in the Erie service area based on historical data.

Table 3-12. Summary of Recommended 10 and 20 Year Design Values

Parameter	2028	2038
Projected Population	49,226	80,184
Avg. Day Influent Flow (MGD)	2.80	4.56
Max. Month Influent Flow (MGD)[a]	3.03	4.93
Avg. Day Influent BOD Loading (lb/day)	6,997	11,398
Max Month Influent BOD Loading (lb/day)	9,376	15,273
Avg. Day Influent TSS Loading (lb/day)	7,193	11,717
Max Month Influent TSS Loading (lb/day)	9,709	15,815
Avg. Day Influent Ammonia Loading (lb/day)	840	1,368
Max Month Influent Ammonia Loading (lb/day)	1,114	1,814
Avg. Day Influent TP Loading (lb/day)	443	722
Max Month Influent TP Loading (lb/day)	618	1,007
Max Month RAS Flow (MGD)[b]	3.03	4.93
Max Month RAS Flow (lb/day)[b]	346,202	563,291
Max Month WAS Flow (gpd)[b]	102,711	160,650
Max Month WAS Flow (lb/day)[b]	11,700	18,300
Max Month Dewatered Solids Flow (lb/day)[c]	14,040	21,960

Table 3-12. Summary of Recommended 10 and 20 Year Design Values		
Parameter	2028	2038
[a] Based on 61.5 gpcd wastewater generation rate per capita. [b] Based on projected solids flow rates provided by Kruger. Assumes secondary treatment expansion. [c] Assumes no change in existing solids treatment process. Based on a 1:5 ratio of lime to WAS solids use. See chapter 6.		

Contents

4 Regulatory Drivers ... 4-1

- 4.1 Introduction ... 4-1
- 4.2 Water Quality Drivers ... 4-1
  - 4.2.1 Current Permit ... 4-1
  - 4.2.2 Anticipated Future Permit Limits ... 4-2
  - 4.2.3 Summary of Anticipated Effluent Limits ... 4-7
- 4.3 Biosolids Drivers ... 4-7
  - 4.3.1 Metals Criteria ... 4-8
  - 4.3.2 Pathogen Criteria ... 4-10
  - 4.3.3 Class B Biosolids ... 4-10
  - 4.3.4 Class A Biosolids ... 4-11
  - 4.3.5 Vector Attraction Reduction ... 4-12
  - 4.3.6 State of Colorado Biosolids Regulations ... 4-13
  - 4.3.7 Potential Changes to EPA Part 503 Biosolids Criteria ... 4-13
  - 4.3.8 Technology Trend Considerations ... 4-17
  - 4.3.9 Summary of Biosolids Drivers ... 4-18
- 4.4 Other Permitting Drivers ... 4-18
  - 4.4.1 Stormwater Management ... 4-18
  - 4.4.2 Air Permitting ... 4-19
  - 4.4.3 Regulatory Agency Coordination ... 4-19
- 4.5 Summary of Regulatory Drivers ... 4-20

Tables

Table 4-1. Policy 17-1 Incentive Program Requirements ... 4-4

Table 4-2. Nutrient-Related Effluent Standards (Regulation 85) and In-Stream Nutrient Values (Regulation 31) ... 4-4

Table 4-3. Numeric Nutrient Criteria and Limits of Wastewater Technology ... 4-5

Table 4-4. Summary Comparison of Ammonia Criteria at pH 7 and Temperature 20 degC, and pH 8 and Temperature 25 degC ... 4-5

Table 4-5. 40 CFR Part 503 Pollutant Concentration (PC) Biosolids ... 4-9

Table 4-6. 40 CFR Part 503 Maximum Allowable Metal Concentrations and Cumulative Pollutant Loading Rates (CPLR) ... 4-9

Table 4-7. Alternatives for Meeting Part 503 Class B Requirements ... 4-10

Table 4-8. Site Restrictions for Class B Biosolids Application ... 4-11

Table 4-9. Alternatives for Meeting Part 503 Class A Requirements ... 4-12

Figures

Figure 4-1: Summary of Anticipated Regulatory Requirements ... 4-23

This page is intentionally left blank.

4 Regulatory Drivers

4.1 Introduction

The purpose of this chapter is to present anticipated water quality, biosolids and air quality compliance standards, and forecast the potential changes to these regulatory requirements that could affect the design and operation of the Town of Erie (Town) North Water Reclamation Facility (NWRF). The following regulatory drivers could potentially affect the NWRF operations, and include local, regional and national regulatory drivers that either exist or may exist through the 2038 planning period.

4.2 Water Quality Drivers

The NWRF currently discharges treated effluent into Boulder Creek, which is a sub-basin to the South Platte River. At the discharge point location, the Creek is classified as Aquatic Life Warm Water- 2, Recreation- 1b, Agriculture, and is designated as Use Protected.

Surface water quality is monitored, permitted and controlled by the Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (WQCD). The Colorado Water Quality Control Commission (WQCC) holds primary authority to establish water quality regulations to meet the goals of the Colorado Water Quality Control Act of 1973, as amended. The WQCC has delegated responsibility for implementing the water quality regulations to the WQCD of CDPHE. Colorado regulations governing surface water quality currently consist of three tiers including:

1. Use classifications,
2. Water quality standards, and
3. Effluent discharge permits.

Colorado surface waters have been assigned use classifications to protect all current and future uses and maintain the highest water quality possible. The WQCC has established water quality standards to protect and maintain designated uses corresponding to each use classification.

4.2.1 Current Permit

The NWRF operates under Colorado Discharge Permit System Permit Number CO-0048445 which was issued on March 24, 2015 and was scheduled to expire on January 31, 2016. However, the permit has been administratively extended as CDPHE is currently working on a permit renewal that will incorporate the Regulation 85 nitrogen and phosphorus limits.

The current permit establishes maximum limits for Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), *E. coli*, pH, total residual chlorine, oil and grease, ammonia, selenium, cadmium, chromium, arsenic, iron, lead, manganese, nickel, silver, copper, uranium, zinc. Minimum removals of BOD and TSS (85 percent) are also identified. The NWRF is also required to monitor temperature. Whole effluent toxicity

(WET) tests are required for chronic exposure. The facility is permitted for a design hydraulic capacity of 1.5 million gallons per day (MGD) (30-day average) and an influent BOD_5 loading of 3,223 pounds per day (30-day average). Based on the projected flows and loads noted previously, it is expected the facility will exceed the influent flow and BOD_5 limit within the 20-year planning window of this study.

Nitrogen

The current NWRF discharge permit does not include a limit on nitrate or total inorganic nitrogen (TIN), however, it is expected the next permit (likely in 2019 or 2020) will include the Regulation 85 limits for TIN of 15 mg/L.

Phosphorus

At present, the NWRF does not have discharge limits for phosphorus, however, it is expected the next permit (likely in 2019 or 2020) will include the Regulation 85 limits for total phosphorus (TP) of 1.0 mg/L.

Temperature

In 2007, the WQCD implemented basin-wide interim numeric temperature standards for each drainage basin within Colorado. Segment-specific temperature standards were implemented in 2008 for the Upper and Lower Colorado River Basins and in 2009 for the South Platte River Basin. In May 2009, the WQCD developed a Draft Final Action 2010 303(d) Listing Methodology, which describes how WQCD will regulate temperature based on chronic standards, acute temperature standards and excursions from temperature standards. Regulation 38 establishes classification and numeric standards for river basins and tributaries. The regulation describes the temperature numeric standard as:

“Temperature shall maintain a normal pattern of diurnal and seasonal fluctuations with no abrupt changes and shall not increase in temperature of a magnitude, rate and duration deemed deleterious to the resident aquatic life.”

Based on Regulation 38, Boulder Creek is classified as a Warm Water Aquatic Life 2 which results in a maximum weekly average temperature of 27.5 degC for the months of March through November and 13.7 degC for the months of December through February. Additionally, the regulation provides a daily maximum temperature of 28.6 degC and 14.3 degC, respectively for the same months listed previously. The current permit requires The Town to monitor and report the effluent temperature on a continuous basis. It is expected CDPHE will begin the implementation of temperature into regulations in 2027 and the results should be closely monitored by the Town.

4.2.2 Anticipated Future Permit Limits

The Environmental Protection Agency (EPA) has been working with states to reduce nutrient levels in wastewater treatment plant discharges. The emphasis being placed on developing numeric nutrient criteria is specifically tied to the control of “nitrogen and phosphorus pollution”. The intent of numeric nutrient criteria is to ensure a level of water quality that will protect the beneficial uses of these water bodies. The presence of nitrogen and phosphorus compounds in surface waters leads to a phenomenon referred to as eutrophication. Eutrophication is characterized by an abundant accumulation of nutrients that support a dense growth of algae and other organisms, the decay of which depletes the shallow waters of oxygen. Nitrogen and phosphorus criteria are set so that they protect streams from the impacts of eutrophication, which include both nuisance algae growth and reduced dissolved oxygen levels which impact fish and aquatic life.

Regulations 85 and 31

CDPHE chose to develop its own nutrient quality rules, which were adopted by the WQCC in May 2012. The State adopted a phased approach to establishing numeric nutrient standards throughout Colorado. These regulations set TP and TIN permit limits for the largest wastewater dischargers (>2 MGD) and set phosphorus and nitrogen interim values for both lakes and reservoirs and rivers and streams.

The first phase is implementation of CDPHE Regulation 85, which set interim effluent standards for TP of 1.0 mg-P/L and total inorganic nitrogen (TIN) of 15 mg-N/L, respectively. The permit limits will be incorporated into permits at the next renewal and compliance schedules will be used to allow the permittee time to come into compliance with these limits. CDPHE has recently indicated that dischargers to the South Platte River watershed basin will have their permits updated in 2019. As such, it is anticipated that the NWRF will be required to meet the Regulation 85 TIN and TP requirements in the next few years.

The second phase of CDPHE's roll-out of nutrient quality criteria is implementation of Regulation 31. This regulation sets interim annual median in-stream nutrient quality values, and the rule was approved with the presumption that these values would not be established as definitive water quality criteria until 2027 except in very limited cases. The in-stream TP and Total Nitrogen (TN) values for warm water streams are 0.17 mg-P/L and 2.01 mg-N/L, respectively.

However, to provide utilities with near-term certainty of regulatory requirements and additional compliance schedule, CDPHE has implemented Policy 17-1 - Voluntary Incentive Program for Early Nutrient Reductions. The purpose of the program is to encourage facilities to reduce TP and TIN below Regulation 85 required limits and in exchange the facility will receive and extended compliance schedule. By reducing the TP and TIN effluent concentration early, a facility can receive a maximum of an additional 10 years on top of the 5 years typically provided to comply with new regulations. This can result in deferring compliance with Regulation 31 standards. Table 4-1 summarizes the Policy 17-1 requirements.

Table 4-1. Policy 17-1 Incentive Program Requirements		
Parameter	**Regulation 85**	**Incentive Target**
TP (mg-P/L) Annual Median	≤1.0 mg/L	≤0.7 mg/L
Months Earned	0	12 for each calendar year
TIN (mg-N/L) Annual Median	≤15	≤7 mg/L
Months Earned	0	12 for each calendar year
The scale for earning months is linear based on annual median. For example, if a facility's annual median concentration is 0.85 mg/L total phosphorus, the facility is eligible to earn incentive credit for that year. Based on the linear scaling of the total phosphorus median, the facility would earn six months toward a compliance schedule. The months of incentive credit from each year will be summed at the end of the 10-year period and rounded down to the next whole month. Partial months will not be incorporated into compliance schedules.		

Table 4-2 summarizes the regulatory requirements of Regulations 85 and 31. One advantage to Colorado's phased approach to implementing nutrient rules is that it provides time for both water quality assessment and treatment technology initiatives to be developed, proven and rolled out into the marketplace.

Table 4-2. Nutrient-Related Effluent Standards (Regulation 85) and In-Stream Nutrient Values (Regulation 31)		
Parameter	**Regulation 85 (Effluent Standard)**	**Regulation 31 (Warm Water In-Stream Standard)**
TP (mg-P/L)	1.0 (1)	0.17 (1)
TIN (mg-N/L)	15 (1)	NA
TN (mg-N/L)	NA	2.01 (1,2)
Attached Algae Chlorophyll a, milligrams per square meter (mg/m^2)	NA	150
[1] Running Annual Median: The median of all samples taken in the most recent 12 calendar months [2] Determined as the sum of nitrate as N, nitrite as N, and ammonia as N		

The TN concentration presented in Regulation 31 is lower than most treatment technologies are capable of achieving if applied to "end of pipe". Attainment of effluent limits based on predicted in-stream numeric criteria at the point of discharge may be possible for phosphorus, but to get to levels below 3 mg/L for total nitrogen will require denitrification filters and/or effluent membrane filtration. Table 4-3 provides a summary of the effluent limits that can be met for nitrogen and phosphorus for different available technologies.

CDPHE has acknowledged the fact that the nitrogen limit may not be attainable and has discussed the inclusion of variances based on "limits of technology". Based on the current discussions, limit of technology for nitrogen removal is considered enhanced nutrient removal (see Table 4-3). For phosphorus removal, an additional filtration step might be required. However, facilities which do not currently meet the limit of technology standard are expected to be required to implement these improvements.

Table 4-3. Numeric Nutrient Criteria and Limits of Wastewater Technology

Parameter	Typical In Stream Nutrient Criteria	Typical Municipal Raw Wastewater	Standard Secondary Treatment	Typical Advanced Treatment Nutrient Removal	Enhanced Nutrient Removal	Limits of Treatment Technology
TP (mg-P/L)	0.020 to 0.050	4 to 8	4 to 6	1	0.25 to 0.50	0.03 to 0.08
TN (mg-N/L)	0.3 to 0.6	35 to 50	20 to 30	10	4 to 6	3 to 4

Revised Federal Ammonia Criteria

The EPA released a revised freshwater ammonia criteria first issued for public comment in December 2009. The revised criteria update the current 1999 ammonia criteria included in most state water quality standards and lead to more stringent effluent ammonia limits in NPDES permits for many wastewater treatment facilities.

The 1999 criteria are based on ammonia toxicity to fish and whether or not sensitive fish species are present in the water body. Revised ammonia criteria are being proposed for the protection of certain species of freshwater unionid mussels and snails, which recent studies have shown to be more sensitive to ammonia toxicity than fish. The revised criteria include a bifurcated criteria approach, with different sets of acute and chronic values depending on mussels being present or absent in the water body.

Table 4-4 provides a comparison of the 1999 criteria with what EPA originally published as a draft revision in 2009 and with the final 2013 criteria.

Table 4-4. Summary Comparison of Ammonia Criteria at pH 7 and Temperature 20 degC, and pH 8 and Temperature 25 degC

Criteria Duration	1999 Criteria Based on Juvenile Salmonids		2009 Draft Revised Criteria Mussels Present		Final 2013 Criteria Single Criteria Mussels Present	
	pH 8, Temp=25degC	pH 7, Temp=20degC	pH 8, Temp=25degC	pH 7, Temp=20degC	pH 8, Temp=25degC	pH 7, Temp=20degC
Acute (mg/L)	5.6	24	2.9	19	2.6	17
Chronic (mg/L)	1.2	4.5	0.26	0.91	0.56	1.9

States are now in the process of adopting and incorporating the revised criteria into their state water quality standards. The state adoption process typically is a two to three year process initiated during the states' triennial review of their water quality standards. It is expected revised criteria will start to appear in Colorado water quality standards in 2027.

Temperature

The Town is currently reporting effluent temperature as noted previously. It is expected that some form of a temperature standard will be included in permits issued after 2027. Metro Wastewater Reclamation District and the City of Boulder have already had negotiations with CDPHE regarding this issue and received site specific variances. This approach should also be implemented by the Town as the cost for cooling effluent can be extremely costly.

Conventional Pollutants

The conventional pollutant parameters that the Town currently monitors are BOD, TSS, *E. coli*, pH, total residual chlorine, oil and grease. Based on the current regulatory environment, it is not anticipated that parameters will change during this planning period.

Trace Inorganic and Organic Constituents of Concern

In addition to conventional pollutants, such as BOD or ammonia, that are present in significant concentrations, there are a number of trace inorganic and organic constituents for which future standards could be set at very low levels. These constituents include a diverse group of relatively unknown and unmonitored chemicals, such as pharmaceuticals, personal care products, endocrine-disrupting compounds (EDCs) and other trace organics that have emerged as potential contaminants of concern. Currently, state and EPA regulators have established water quality standards for the following constituents:

- Nonylphenol
- Arsenic
- Selenium
- Mercury
- Perchlorate
- 1,4-dioxane
- N-nitrosodimethylamine (NDMA)
- Copper
- Cadmium
- Dissolved iron
- Trace wastewater constituents
- Aluminum

Water quality stream standards exist for these constituents, therefore effluent limits may be included in future permits. Among other solutions for effluent compliance, source control of these constituents may be the most viable methodology. Note that for some of these parameters, the compliance strategy will include source control through Industrial Pretreatment Program (IPP).

4.2.3 Summary of Anticipated Effluent Limits

As noted previously, the current NWRF permit expired on January 31, 2016, but has been administratively extended. The new permit will include the Regulation 85 limits for TIN and TP of 15 mg/L and 1.0 mg/L, respectively. Typically, CDPHE includes a compliance schedule for implementing the improvements needed to meet the revised nutrient limits. It is expected the Town will have 3-5 years to meet these revised limits. The Regulation 31 limits are not anticipated to be included in a permit until 2027. However, Policy 17-1 provides an opportunity to extend the compliance to 2042. At this point, it is unclear as to how these limits will be incorporated into discharge permits but it is expected some form of additional phosphorus and nitrogen removal will be required. For the purposes of this evaluation and planning for the next 20-year window, it is assumed the effluent will need to meet the following:

- Total inorganic nitrogen ≤ 15 mg/L (Regulation 85)
- Total phosphorus ≤ 1.0 mg/L (Regulation 85)
- Ammonia ≤ 1 mg/L (based on 2013 Revised Federal Ammonia Criteria and implemented in approximately 2027)
- Temperature – Less than 13.7 degC during shoulder months (Based on Regulation 38 for Boulder Creek - site specific variance needed)
- Limit for selenium, copper, cadmium, arsenic, nonylphenol and mercury

4.3 Biosolids Drivers

EPA policy is to promote the beneficial use of biosolids while maintaining environmental quality and protecting public health (EPA, 2003). The Clean Water Act Amendments of 1987 required EPA to develop new regulations pertaining to sewage sludge/biosolids. In February, 1993, EPA published 40 CFR Part 503 (i.e., Part 503). The Part 503 Rule is a complex, risk-based assessment of potential environmental effects of pollutants that may be present in biosolids (EPA, 1995). These guidelines regulate pollutant and pathogen concentrations as well as vector attraction reduction (VAR). The guideline defines biosolids as Class A or Class B, depending on the potential level of pathogens. Class A biosolids must meet strict pathogen standards and can be used with no restrictions, while Class B biosolids can meet less stringent pathogen requirements, with application restricted to crops with limited human and animal exposure. Biosolids in both classes must meet VAR requirements.

The Part 503 Rule applies to biosolids applied to agricultural and non-agricultural land, biosolids placed in or on surface disposal sites and biosolids that are incinerated. Biosolids that are landfilled or used as a cover material at a landfill are subject to federal requirements in 40 CFR Part 258. The general provisions of the Part 503 Rule provide basic requirements for biosolids applied to land including pollutant limits, management practices, operational standards, monitoring, record keeping and reporting.

In spite of the nearly unblemished experience with biosolids land application programs, nationally and internationally, there continues to be pressures to question the long-term safety of this practice, both to the environment and to human health. It is known that biosolids can contain numerous substances with the potential to be harmful, and there is ongoing debate on the relative risks.

The National Academy of Sciences (NAS) completed an assessment of the science that supports the Part 503 Rule in 2002, and concluded that there is no evidence that current biosolids management practices under existing regulations are not safe, but that more research is required to update the science behind the regulations (NAS 2002). NAS concerns included the synergistic effects of chemical pollutants and pathogens, and other pathogens and chemical pollutants not considered in the risk assessment of the Part 503 Rule.

EPA continues to review the Part 503 regulations and is expected to issue an updated version in the next five to ten years. Additionally, EPA is performing a sewage sludge survey to assess a variety of compounds that are not currently regulated under the Part 503 rule. It is possible that additional compounds may be regulated under the new biosolids rule. Following is a summary of the current state of regulations and issues of potential concern.

4.3.1 Metals Criteria

Two approaches to meeting the Part 503 metals limits are allowed:

- A maximum concentration in the biosolids must be met, or
- A maximum cumulative amount of metals added to the soil from biosolids application must be met.

Biosolids meeting the Part 503 requirements by the first method are called pollutant concentration (PC) biosolids, and limits are shown in Table 4-5. If biosolids metals meet these concentrations, no record keeping of cumulative loading to soils is required for land application. If PC biosolids also meet Class A pathogen reduction standards, they are considered exceptional quality (EQ), and may be distributed to the general public, although some common sense restrictions should be applied because of public perception issues.

Table 4-5. 40 CFR Part 503 Pollutant Concentration (PC) Biosolids	
Pollutant	**Allowable Concentration (mg/kg monthly average)**
Arsenic (As)	41
Cadmium (Cd)	39
Copper (Cu)	1,500
Lead (Pb)	300
Mercury (Hg)	17
Nickel (Ni)	420
Selenium (Se)	100
Zinc (Zn)	2,800

Biosolids meeting the metals limits of the Part 503 regulations by the second method are called cumulative pollutant loading rate (CPLR) biosolids. Column two of Table 4-6 shows the maximum allowable metals concentrations in any biosolids applied to land. Columns three and four of Table 4-6 show the maximum allowable cumulative loading rates of metals applied to land.

Technologies to produce Class A and Class B biosolids generally do not decrease concentrations of metals in biosolids, unless other material is mixed with biosolids such as amendment material for composting.

An effective industrial pretreatment program is the key to complying with Part 503 metals limits, as industrial inputs into the collection system are the primary source of metals. EPA is currently considering whether other compounds should be regulated in biosolids; however, guidance is not currently available for these compounds.

Table 4-6. 40 CFR Part 503 Maximum Allowable Metal Concentrations and Cumulative Pollutant Loading Rates (CPLR)			
Pollutant	**Allowable Concentration (mg/kg dry wt.)**	**CPLR (kg/ha)**	**CPLR (lb/ac)**
Arsenic (As)	75	41	36.5
Cadmium (Cd)	85	39	35
Copper (Cu)	4,300	1,500	1,339
Lead (Pb)	840	300	267
Mercury (Hg)	57	17	15
Nickel (Ni)	75	--	--
Selenium (Se)	420	420	375
Zinc (Zn)	100	100	89

4.3.2 Pathogen Criteria

Two classes of biosolids are defined by EPA that can be land applied, Class B and Class A. Class B biosolids may have low levels of pathogens and have restrictions imposed on public access and crop harvesting after land application. Class A biosolids have stringent limits for pathogens and can be used without any additional public contact restrictions. Class B and Class A biosolids are described in the following sections.

4.3.3 Class B Biosolids

Class B biosolids are the predominant class of biosolids produced in the US (USEPA, 1999; NEBRA, 2007). Common treatment technologies, such as aerobic and anaerobic digestion, are used at many municipal wastewater treatment plants to inactivate the vast majority of potential pathogens in biosolids (the Town currently uses lime and heat to produce Class B biosolids). However, the biosolids are not considered "pathogen-free," and EPA requires that specific management practices be employed to protect the public. Class B biosolids must also meet the same vector attraction reduction requirements as Class A biosolids.

Class B biosolids must meet one of several pathogen destruction alternatives as noted in Table 4-7.

Table 4-7. Alternatives for Meeting Part 503 Class B Requirements

Alternative	Description
Alternative 1	Meet monitoring requirements for fecal coliform (geometric mean fecal coliform density must be less than 2 million coliform forming units (CFU) or most probable number (MPN) per gram of biosolids)
Alternative 2	Employ a Process to Significantly Reduce Pathogens (PSRP)
Alternative 3	Employ a process equivalent to a PSRP

PSRPs include the following:

- Anaerobic digestion between 15 days at 35°C (95°F) to 60 days at 20°C (68°F).
- Aerobic digestion between 40 days at 20°C (68°F) to 60 days at 15°C (59°F).
- Air drying for at least 3 months.
- Composting: temperature of the sludge must be 40°C (104°F) or higher for at least five days. For four hours of that period, the temperature must be 55°C (131°F) or higher.
- Lime stabilization: the pH of the sludge must be raised to 12 for at least two hours, and must remain above 11.5 for 24 hours.

Alternative 3 for Class B biosolids requires approval of the USEPA or state regulatory agency. The regulating authority makes the decision on whether or not a process should be considered as equivalent to a PSRP. Both equivalent processes and PSRPs must meet specified pathogen requirements, as well.

Biosolids treatment must include a method for reducing the attraction of vectors. Alternatives depend on the method of treatment and include 38 percent volatile solids

(VS) destruction, and a specific oxygen uptake rate of less than 1.5 mg oxygen/ hour/ gram total solids. Meeting the 38 percent VS destruction criteria for VAR is usually easily achieved during anaerobic digestion due to the high efficiency of the process.

Management practices are required to limit public and animal contact after Class B biosolids are applied and to allow natural processes to further inactivate potential pathogens. The management practices for Class B biosolids are in addition to the general management requirements specified in Subpart A of the Part 503 regulations, and are summarized in Table 4-8.

Table 4-8. Site Restrictions for Class B Biosolids Application

Land/Crop Characteristic	Regulatory Criteria (State and Federal)
Land with a high potential for public exposure	Public access restricted for 1 year after biosolids application
Land with a low potential for public exposure	Public access restricted for 30 days after biosolids application
Food crops, feed crops or fiber crops	Not harvested for 30 days after biosolids application
Food crops with harvested parts that touch the biosolids/soil mixture and are totally above the land surface (e.g., melons, cucumbers)	Not harvested for 14 months after biosolids application
Food crops with harvested parts below the land surface (e.g., root crops such as potatoes, carrots, radishes)	Not harvested for 20 months after biosolids application
Animal grazing on a site	Restricted for 30 days after biosolids application
Turf placed on land with high potential for public exposure or a lawn unless otherwise specified by the permitting authority	Restricted for 1 year after biosolids application

4.3.4 Class A Biosolids

Class A pathogen reduction requirements include fecal coliforms of less than 1,000 Most Probable Number (MPN) per gram Total Solids (TS) or Salmonella of less than 3 MPN per 4 grams TS. Alternatives for meeting Class A pathogen requirements are provided in Table 4-9.

Thermal treatment means a specific time-temperature requirement must be met as specified by the 503 regulations. All biosolids particles processed using this alternative must be subjected to the EPA specified time-temperature regime, which means that batch or plug-flow processing must be employed: continuous flow processes with a detention time on, or above, the time-temperature curve are not acceptable.

Table 4-9. Alternatives for Meeting Part 503 Class A Requirements	
Alternative	**Description**
Alternative 1	Thermally treated (must meet specific time-temperature requirements depending on solids concentration)
Alternative 2	High pH-high temperature (lime stabilization followed by air drying)
Alternative 3	"Other Processes": sampling required
Alternative 4	"Unknown Processes": sampling required
Alternative 5	Use of a Process to Further Reduce Pathogens (PFRP)
Alternative 6	Process equivalent to PFRP (requires approval of EPA's Pathogen Equivalency Committee)

Class A biosolids requirements for Alternatives 3 and 4 (see Table 4-9) rely on enteric virus and helminth ova testing, which can be expensive and time-consuming (4 weeks for helminth ova, and 2 weeks or longer for enteric viruses). There are also a limited number of accredited laboratories capable of performing these analyses. A number of states have eliminated the availability of Alternatives 3 and 4 due to the difficulty in meeting the requirements.

A high pH-high temperature process is defined as the three following conditions:

- A pH of greater than 12 for at least 72 hours
- Retaining the temperature of the sludge above 52 degC for at least 12 hours while the pH is above 12
- Air drying to over 50 percent solids after the 72-hour period of elevated pH

Processes to Further Reduce Pathogens (PFRPs) to produce Class A biosolids include composting, heat drying, heat treatment, thermophilic aerobic digestion (also known as autothermal thermophilic aerobic digestion or ATAD), beta ray irradiation, gamma ray irradiation and pasteurization. New processes not specified by the EPA can be considered equivalent to a PFRP. The permitting authority is responsible for determining if a process is equivalent, and this is generally the Pathogen Equivalency Committee (PEC) of the USEPA.

Although the State of Colorado still allows the use of Alternative 3 & 4, the USEPA is considering eliminating their use to achieve Class A. In addition, many states have already eliminated the testing to achieve Class A. The PEC is notoriously slow in considering new PFRP Equivalency and with the current deep budget cuts to USEPA the likelihood of new processes to consider is somewhat remote.

The NWRF was designed to use a lime stabilization system to produce Class A biosolids. However, the system has only been able to achieve a Class B product causing the Town to haul a Class B product.

4.3.5 Vector Attraction Reduction

Vectors such as flies are attracted to putrescible organic matter and can facilitate disease transmission. Federal and state biosolids regulations require that certain standards be met to reduce the attractiveness of biosolids to vectors. Vector attraction reduction (VAR) requirements for Class A biosolids are the same as for Class B requirements. Alternatives depend on the method of treatment and include 38 percent volatile solids destruction, a specific oxygen uptake rate of less than 1.5 mg oxygen per hour per gram total solids and others. In general, pathogen reduction must be achieved prior to or at the same time as vector attraction reduction for biosolids to be considered Class A. Problems with pathogen re-growth led EPA to include this provision.

4.3.6 State of Colorado Biosolids Regulations

The CDPHE WQCC's 5 CCR 1002-64 Biosolids Regulation (Regulation 64) has a stated purpose of:

"The purpose of these regulations is to establish requirements, prohibitions, standards and concentration limitations on the use of biosolids as a fertilizer and/or organic soil amendment in a manner so as to protect the public health and prevent the discharge of pollutants into state waters."

Any domestic wastewater treatment works, irrespective of whether the domestic wastewater treatment works is required to obtain a CDPS permit when biosolids generated at the domestic wastewater treatment works are withdrawn for beneficial use. The regulations apply to any person treating, manipulating or applying biosolids to land for beneficial purposes. The regulation does not apply to industrial sludges, industrial septage, wastewater grit and screenings, hazardous sewage sludge, grease, and water treatment sludges.

Regulation 64 was first adopted on November 2, 1993 which was just over eight months after the USEPA 40 CFR Part 503 Regulation was promulgated. Unlike the 503 Regulation, Regulation 64 has undergone 10 Amendments the latest being February 8th 2010. Regulation 64 follows the 503 regulation quite closely and is considered an "integration of that portion of the Federal Part 503 regulations dealing with beneficial land application with the criteria and administrative processes from the State of Colorado's Domestic Sewage Sludge Regulations."

One unique feature of Regulation 64 is Notices of Authorization that are issued on a site by site basis and focuses on the management, monitoring and reporting requirements. This allows the State of Colorado to prohibit authorization of application that would potentially violate any Colorado Water Quality Standards for surface or groundwater in specific areas.

Another unique feature of Regulation 64 is that additional sources of nitrogen such as manures, fertilizers or other sources must be accounted for in the determination of the appropriate application rate for the biosolids. The Regulation also focuses on what application is appropriate for the degree of slope as well as on frozen or snow covered agricultural land.

4.3.7 Potential Changes to EPA Part 503 Biosolids Criteria

As part of Section 405(d)(2)(C) of the Clean Water Act, EPA is required to review its sewage sludge regulations every two years. The purpose of the review is to identify additional toxic pollutants that may be present in the sewage sludge and, if appropriate, to promulgate regulations for those pollutants (i.e., occurrence and risk evaluations).

Metals

Based on the 2003 Biosolids Biennial Review, EPA identified a subset of 15 pollutants that need to be further evaluated. EPA subsequently reduced the list to nine pollutants (barium, beryllium, manganese, silver, fluoranthene, pyrene, 4-chloroaniline, nitrate and nitrite) for continued analysis. EPA expects to complete the evaluation of these pollutants, plus molybdenum, using available data and the recently released Targeted National Sewage Sludge Survey (TNSSS) results. The objective of the TNSSS is to determine which analytes are present in sewage sludge, and to obtain national estimates of the concentrations of the selected analytes.

Molybdenum

Current interest seems to be focused on molybdenum, and potentially revising its numeric standard for land-applied biosolids. Elevated levels of molybdenum can create a disorder known as molybdenosis in grazing livestock. Molybdenosis is a copper-deficiency disease that occurs when molybdenum affects the physiological availability of copper, particularly in cattle and sheep. Regulation 64 limits the concentration of molybdenum in biosolids to 75 milligrams per kilogram (mg/kg). However, there is no monthly limit or cumulative land application loading rate restrictions for molybdenum.

Radionuclides

Another potential change to the biosolids program may be the required monitoring and/or limits for radionuclides. The WQCD has stated it will form a work group to evaluate the need to include technologically enhanced, naturally occurring radioactive materials requirements in Regulation 64. Wastewater treatment plants that receive water treatment residuals can have elevated radionuclide levels, such as radium 226/228, and uranium.

Aluminum

In the early 1990s, there was significant discussion regarding whether aluminum would be included as one of the regulated metals in Part 503. Based on risk and occurrence considerations, EPA ultimately made the decision not to include aluminum as a regulated metal and there has been no significant movement in that direction since then.

Aluminum and iron salts are used to control the growth of certain filamentous organisms (e.g., M.Parvacella) or for tertiary treatment. Such uses will increase the concentrations of aluminum in the biosolids. The Town should include aluminum on its watch list of future parameters of concern, more for its potential effect on the beneficial use of biosolids and as a final effluent limit. Ferric salts are also effective at phosphorous removal and could be used instead of aluminum. If aluminum limitations are placed on final effluent or biosolids they may limit the beneficial use land application program.

Pathogen Re-Growth and Reactivation

Recent research by the Water Environment Research Foundation (WERF) has shown that fecal coliform, the indicator organism commonly used for pathogens, sometimes reactivates and/or re-grows after mechanical dewatering of solids. This has occurred with a variety of anaerobic digestion processes, both Class B and Class A. Research is ongoing to further understand the mechanisms and causes of this phenomenon.

Pathogen content in compost and compost like products are of concern in a number of parts of the country and Local Enforcement Agencies and other regulatory agencies are being forced to require additional monitoring and provide additional scrutiny at sites. This not only adds cost to the overall management of the biosolids, but also potentially opens the facility to negative public reactions and third party law suits.

Additionally, the EPA is continually evaluating new research on pathogen reduction and may revise the regulations such that the requirements for land application are similar to Class A biosolids. At this time, neither the EPA nor CDPHE have indicated this is in the near future but it is something to watch closely over the next 10 years.

Microconstituents of Concern

The presence of trace organic chemicals (TOrCs) in municipal biosolids in the U.S. has received considerable attention by the public and scientific community over the last several years. Of particular concern is whether the presence of TOrCs in biosolids results in significant risks to public health and the environment upon land application. While the EPA has evaluated the risks associated with dioxins present in biosolids-amended soils, to date, no other TOrCs, particularly those of emerging concern, have been subjected to complete risk assessments. However, there are a growing number of studies being published every year that addresses the occurrence, mobility, persistence, bioaccumulation, toxicity and microbial impacts of biosolids-borne TOrCs in soils. As more scientific data becomes available on this subject it is likely that EPA will start regulating TOrCs that poses clear ecological and human health risk.

Recent studies have found that some TOrCs can leach from fields, particularly when the applied biosolids are not dewatered. Specifically, steroid hormones have recently been shown to have the potential for runoff after heavy rainfall. However, other TOrCs (e.g., polybrominated diphenyl ethers, synthetic musks and some steroidal chemicals) were shown to have low leaching potential.

The persistence of biosolids-borne TOrCs in soils is a result of many processes, but biodegradation is generally considered the dominant process in eliminating TOrCs. Environmental factors such as pH, moisture content, metal cations, temperature and bacterial cell concentration all can affect biodegradation rates. Biodegradation rates of steroidal chemicals are favorably impacted by the presence of biosolids, increased temperatures and adequate (but not excessive) water content in soils. Unfortunately, degradation data for many TOrCs are not yet available for soils and biosolids-amended soils.

Bioaccumulation of some of the TOrCs has been documented, but few studies examined bioaccumulation and bioavailability specifically in biosolids-amended soils. Some TOrCs (tetracycline antibiotics, antimicrobials, fluoroquinolones, synthetic musks and brominated flame retardants) can accumulate in a variety of plants including grass, green onions, cabbage, corn, alfalfa, lettuce, radish, zucchini and carrots. Studies have shown that bioaccumulation of TOrCs in animals, particularly invertebrates such as earthworms, is also possible.

Several studies have indicated that many of the TOrCs found in biosolids can be significantly reduced in concentration if the biosolids are being treated by a combined anaerobic and aerobic digestion process.

Below is a list of the high priority trace organic chemicals present in biosolids-

- Brominated Flame Retardants
- Perflourochemicals - Surface Coatings
- Pharmaceuticals and Personal Care Products
  - Antimicrobials
  - Antibiotics
  - Musks
- Plasticizers - Bisphenol A
- Steroidal Chemicals-Natural and Synthetic hormones
- Surfactants
- Nanoparticles - antibacterial/antifungal agents

Colorado Nitrogen Leaching Index

Nitrogen is an essential nutrient for the growth and survival of plants. In general, plants absorb nitrogen in the form of nitrate from the soil. When soils lack nitrogen, farmers will apply additional amounts to support crop growth. However, excess nitrate not absorbed by plants is susceptible to leaching beneath the crop root zone and entering the groundwater system, where it can become a pollutant.

As part of Regulation 64, application of biosolids cannot exceed the agronomic rate for plant-available nitrogen for the crop cultivated. The National Resources Conservation Service (NRCS), an agency of the United States Department of Agriculture (USDA), developed the Nitrogen Leaching Index Risk Assessment tool, herein called N-index, which quantifies the potential for nitrogen to leach below the crop root zone. The draft N-index Version 3 was drafted September 28, 2012, and serves as a preliminary screening tool for biosolids application on irrigated sites. Although not developed in conjunction with Regulation 64, the N-index provides a means to reduce the potential for nitrate contamination of underlying groundwater.

Colorado Phosphorus Index

Phosphorus is a nutrient that can stimulate algae production in aquatic environments, potentially leading to eutrophication and its negative water quality effects. Therefore, phosphorus transport to surface waters caused by wind or water erosion of soil is a concern that is being addressed by the NRCS. The NRCS has developed a Phosphorus Index Risk Assessment tool to assess the risk of phosphorus loss from agricultural fields treated with organic fertilizers or soil amendments to nearby water resources.

The P index was developed because soil phosphorus testing alone cannot predict the potential for soil erosion and phosphorus losses. Therefore, the P-index accounts for soil characteristics, ground slopes, predicted soil erosion estimates, planned phosphorus application amounts, distances from surface water, and field management strategies. The P-index score is intended to provide a relative risk measurement for phosphorus movement off-site to surface waters. Farms that receive funding through various USDA programs are required to comply with P-index requirements as part of a nutrient management plan as of January 1, 2013.

Since the Town does not receive federal funding through the USDA programs, the P-index requirements will not necessarily affect the Town's biosolids disposal. However, the P-index risk assessment will be required and completed for any private land application sites that Town's biosolids are applied to. If the Town continues to contract hauling with Veris, it will be on the responsibility of Veris to complete this index.

Public Perception

Political divisions and conflicts have emerged over the management of biosolids around the US, particularly in California, Virginia and Pennsylvania. Local ordinances have been passed banning either Class B or all biosolids land application. More organized opposition to current biosolids management practices is compelling utilities to apply biosolids in more remote areas or process solids more extensively in order to manage biosolids in alternative ways.

Agricultural land application programs have a long and successful history in Colorado. CDPHE actively promotes beneficial reuse through land application. There are no pathogen-related regulatory changes on the horizon that would eliminate the ability of the Town to land apply Class B biosolids. The Town is currently paying for hauling of Class B solids, contracted through Veris. A detailed analysis of producing a Class A or Class B biosolids is performed in the Solids Stream chapter of this report.

4.3.8 Technology Trend Considerations

Trends in Europe sometimes portend the future direction of domestic programs. In Europe, public perception related to risks of biosolids land application has resulted in greater focus on energy recovery/combustion technologies such as incineration, cement kilns and gasification.

Recently, the USEPA under the Clean Air Act designated Sewage Sludge as a "Solid Waste". This, plus litigation from environmental groups, forced the Sewage Sludge Incinerator (SSI) Rule to change the monitoring and emission control Maximum Achievable Control Technology (MACT) standards from Rule 112 Standards to Rule 129 Standards. Rule 129 Standards are considerably more stringent. This led to a series of meetings, letter writing campaigns and ultimately a lowering of some of the emission limits and lessening of some of the monitoring whereby facilities with SSIs can achieve compliance. The regulations will lead to modifications in most cases and it will be expensive but they will be able to continue to operate. Because some of these SSI facilities still do not consider these rule changes to be reasonable or appropriate; the National Association of Clean Water Agencies (NACWA) is initiating litigation.

The interpretation of these rule changes is also causing some significant concern from the Water Reclamation Community. First, even though not intended by USEPA, the rule could apply to all combustion of sewage sludge, biosolids and biosolids products which, if enforced, could bring all use of digester gas under new rules and standards. Second, if sludges and biosolids are a solid waste, should they be land applied from a public perception point of view?

4.3.9 Summary of Biosolids Drivers

The future will likely bring both substantial challenges to, and attractive opportunities for, biosolids management. A continuation of substantial existing pressures, along with the emergence of new ones, presents serious challenges to biosolids management likely resulting in the loss, severe restriction and/or increased cost of management options. This includes the persistence of public perception concerns driven by odors, in combination with more emergent public health concerns (such as microconstituents), as well as the emergence of new regulatory actions such as the SSI rule and managing the phosphorus component of biosolids consistent with agronomic rates. Additionally, a report published by the US Environmental Protection Agency's (EPA) Office of Inspector General (OIG) highlighted the potential safety concerns associated with unregulated contaminants in Class B biosolids. However, substantial opportunities also exist for new and expanded biosolids management. The opportunity is largely tied to the repositioning of biosolids as a community resource too valuable to waste in the context of renewable energy needs, urban sustainability interests, population growth, soil depletion and technology improvements. These important and substantial societal trends can equate to a compelling opportunity to reposition the biosolids management and product discussions to overcome entrenched negative positions and perceptions and recognize biosolids as a resource too valuable to waste and only increase with the production of Class A biosolids. Chapter 6 includes an in-depth discussion concerning upcoming trends related to biosolids drivers, as well as further detail regarding the EPA OIG biosolids report, and its potential impacts.

4.4 Other Permitting Drivers

4.4.1 Stormwater Management

Colorado regulates the discharge of stormwater associated with non-extractive industrial activities under provisions of the Colorado Water Quality Control Act (25-8-101 et seq, Colorado Revised Statute, 1973 as amended) and the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251 et seq). The WQCD has recently revised the stormwater discharge permit to combine the light, heavy, and recycling stormwater permits into one permit. The revisions of the general stormwater discharge permit are based on the structure and content of the 2008 EPA Multi-Sector General Permit program. These revisions mainly consist of some new procedural requirements and clarifications to the permit requirements.

A facility that is considered a light industry (a wastewater treatment facility with a design flow of 1.0 MGD or more), typically has a general permit for stormwater discharges associated with non-extractive industrial activity. With this permit, quarterly visual inspections, one of which must take place during a storm event, are required. In addition to inspections for the general stormwater discharge permit, the Town also would perform visual inspections for the Spill Prevention and Control Countermeasures Plan. The stormwater permit typically also requires submission of annual reports to the WQCD detailing the overall compliance with the stormwater permit and its stormwater management plan, and a summary of each comprehensive stormwater facility inspection and any required corrective actions. As part of the permit, collect one sample from each outfall (or necessary monitoring points) is required quarterly, as well as a visual assessment on each sample. Monitoring must occur within 30 minutes of a storm event resulting in a discharge.

However, Erie's stormwater discharge permit was terminated in April of 2017 based on the Town's NWRF meeting various eligibility requirements for permit termination. Should stormwater containment at the site change due to improvements recommended as part of the plant's next expansion plan, a new stormwater discharge permit would be required.

4.4.2 Air Permitting

Air quality drivers that could potentially affect the Town's operations include local, regional and national regulatory drivers that either exist, or may exist, through the planning period.

The State of Colorado Air Pollution Control Division (APCD) regulates air quality and emissions under the Air Quality Control Commission (AQCC) Regulations. The APCD also issues and administers permits to stationary sources of air pollution required to obtain permits. Any stationary source of air pollution that emits or has the potential to emit more than 100 tons per year (tpy) of any regulated air pollutant is required to have an operating permit. In addition, any source that emits or has the potential to emit more than 10 tpy of a hazardous air pollutant, or more than 25 tpy of a combination of hazardous air pollutants, is required to have an operating permit.

Currently, the Town only operates a single emergency backup generator that would be subject to air permitting. As long as the total air pollution from the generator remains below 100 tpy, the facility is exempt from air permitting requirements.

4.4.3 Regulatory Agency Coordination

Any major modifications to the NWRF will require coordination with state and local regulatory agencies. A summary of anticipated regulatory agency coordination activities is provided in the following sections.

CDPHE

CDPHE requires a site application to be submitted for any major changes at a WRF, lift station or major interceptors. The site application process is outlined in Regulation 22, and consists of submission of an application form, preliminary design report, and final design documents for review and approval. This review process is anticipated to take several months to complete, and must be considered within the project schedule for any design work.

In addition to site application approval and design review, any major changes in the process or WRF capacity will also require modification of the discharge permit in accordance with Regulation 61.

A stormwater permit may also be required if more than an acre of land is disturbed during construction.

Weld County

Projects at the NWRF that include major modifications to existing buildings or construction of new buildings will require a building permit from the Weld County Building Department. Design plans should be submitted to the County at 100 percent design for review and approval prior to issuing bidding documents.

Projects that have significant site disturbance will also require a drainage report and grading permit to be submitted and approved.

Boulder County

The Town of Erie is situated within both Weld County and Boulder County. Since the NWRF is located in Weld County limits, and no work is anticipated within the Boulder County limits, review of plan sets is not expected.

North Front Range Water Quality Planning Association (NFRWQPA)

The final Report will be submitted to NFRWQPA for review and approval.

Mountain View Fire Protection District

Projects that impact existing buildings, result in new buildings, or impact site access will require reviewed and approved by the Mountain View Fire Protection District. Design plans should be submitted to the Fire Protection District at 100 percent design for review and approval prior to issuing bidding documents.

FEMA (Federal Emergency Management Agency)

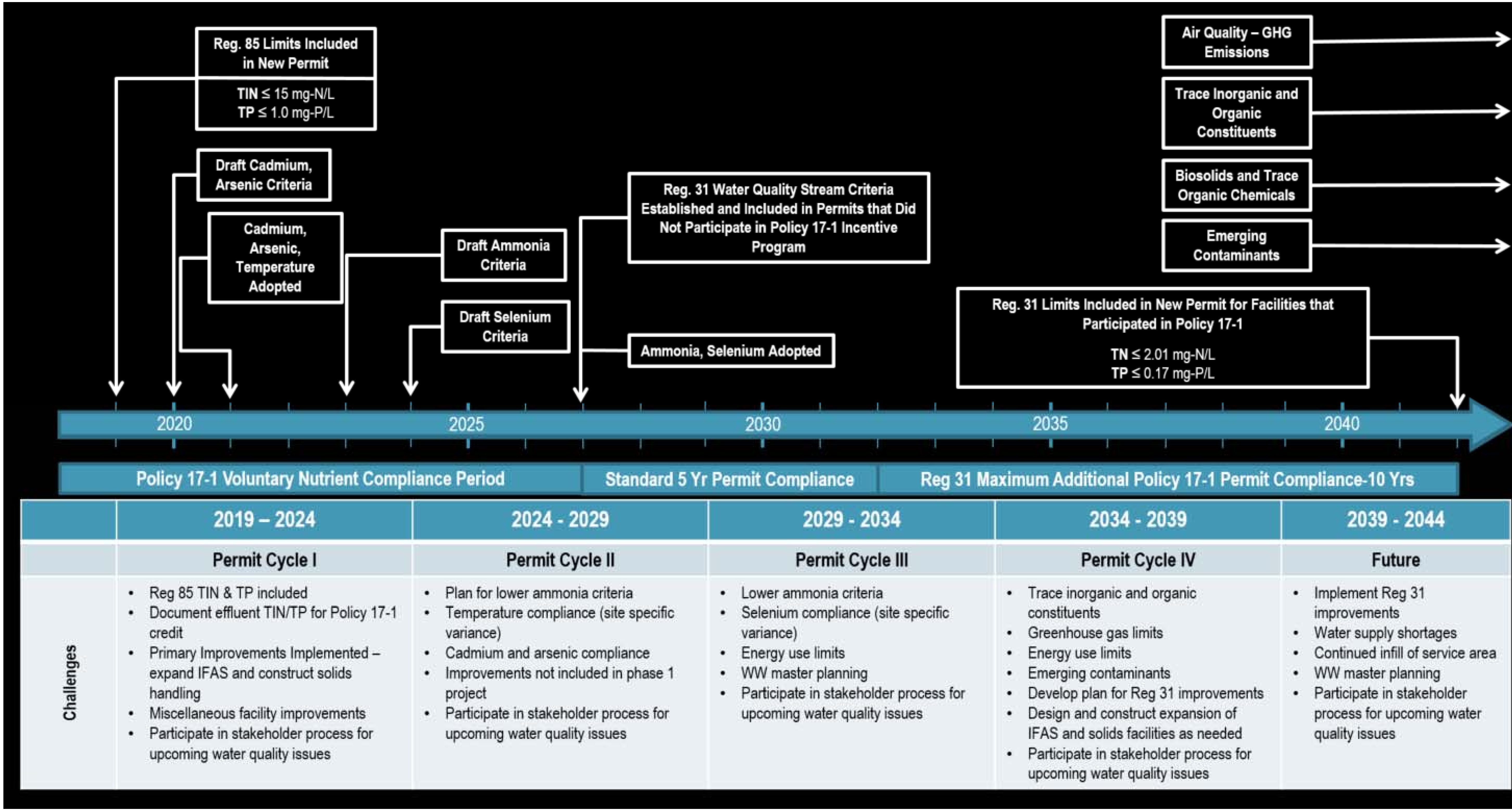
FEMA determines the floodplain boundaries and any modification requirements. Any future expansion of the treatment facilities within the floodplain will require a Letter of Map Revision (LOMR).

4.5 Summary of Regulatory Drivers

Figure 4-1 provides a summary of the anticipated regulatory requirements, the associated permit cycles and challenges associated. Over the next 10 years, the Town has the opportunity to participate in Policy 17-1. By doing so, the Town can gain up to an additional 10 years of compliance schedule on top of the standard 5 years for meeting the requirements of Regulation 31. This is critical as the TN limits currently documented are below the limits of technology. The extended compliance, allows technology to “catch up” to the water quality requirements and provides additional time to develop alternative methods for meeting the limits including nutrient trading.

Based on the current regulatory environment for biosolids, it is anticipated that the industry will gravitate increasingly towards Class A biosolids throughout the next 10 to 15 years. The NWRF currently is experiencing issues with the solids processing system. The energy, time, and chemicals put into the system meet the Class A requirement, however, NWRF is achieving and hauling only Class B. The solids stream process performance chapter evaluates the solids treatment options and recommends whether a Class A or Class B product is validated.

As noted in Figure 4-1, ammonia, temperature, and other emerging contaminants will be evaluated and included in upcoming permits. It is recommended the Town participate in stakeholder groups during the process of developing the draft limits and provide comment to CDPHE.



	2019 – 2024	2024 - 2029	2029 - 2034	2034 - 2039	2039 - 2044
	Permit Cycle I	Permit Cycle II	Permit Cycle III	Permit Cycle IV	Future
Challenges	• Reg 85 TIN & TP included • Document effluent TIN/TP for Policy 17-1 credit • Primary Improvements Implemented – expand IFAS and construct solids handling • Miscellaneous facility improvements • Participate in stakeholder process for upcoming water quality issues	• Plan for lower ammonia criteria • Temperature compliance (site specific variance) • Cadmium and arsenic compliance • Improvements not included in phase 1 project • Participate in stakeholder process for upcoming water quality issues	• Lower ammonia criteria • Selenium compliance (site specific variance) • Energy use limits • WW master planning • Participate in stakeholder process for upcoming water quality issues	• Trace inorganic and organic constituents • Greenhouse gas limits • Energy use limits • Emerging contaminants • Develop plan for Reg 31 improvements • Design and construct expansion of IFAS and solids facilities as needed • Participate in stakeholder process for upcoming water quality issues	• Implement Reg 31 improvements • Water supply shortages • Continued infill of service area • WW master planning • Participate in stakeholder process for upcoming water quality issues

Figure 4-1: Summary of Anticipated Regulatory Requirements

This page is intentionally left blank.

Contents

5 Liquid Stream Process Performance Evaluation and Alternatives Analysis 5-1

5.1 Introduction 5-1

5.2 Objectives and Purpose 5-2

5.3 Summary of Drivers 5-3

5.4 Summary of Design Year Flows and Loads 5-4

5.5 Hydraulic Analysis 5-5

5.5.1 Deviations from Existing Hydraulic Profile 5-6
5.5.2 Future Build-Out 5-7
5.5.3 Process Scenario Configurations 5-7
5.5.4 Scenario 1 – Three IFAS Trains and Two Secondary Clarifiers 5-8
5.5.5 Scenario 2 – Two IFAS Trains and Two Secondary Clarifiers 5-8
5.5.6 Scenario 3 – Three IFAS Trains and One Secondary Clarifier 5-10
5.5.7 Scenario 4 – Two IFAS Trains and One Secondary Clarifier 5-11
5.5.8 Scenario 5 – 2038 Build-Out 5-12
5.5.9 Summary 5-13

5.6 Liquids Stream Process Capacity and Condition Analysis 5-14

5.6.1 Existing Facility Description 5-14
5.6.2 Headworks 5-19
5.6.3 Influent Pumping 5-20
5.6.4 Grit Handling System 5-21
5.6.5 Integrated Fixed Film Activated Sludge (IFAS) Process 5-25
5.6.6 Blowers 5-32
5.6.7 Clarifiers 5-33
5.6.8 Disc Filter 5-34
5.6.9 UV System 5-36
5.6.10 Summary of Existing Liquids System Evaluation 5-37

5.7 Cost Evaluation of Alternatives 5-41

5.8 Non-Economic Evaluation of Alternatives 5-42

5.9 Summary of Liquids Stream Recommendations 5-42

Tables

Table 5-1. Policy 17-1 Incentive Program Requirements 5-3

Table 5-2. Nutrient-Related Effluent Standards (Regulation 85) and In-Stream Nutrient Values (Regulation 31) 5-4

Table 5-3. Erie NWRF 2028 and 2038 Average Annual and Maximum Month Flows and Loads 5-5

Table 5-4: Hydraulic Model Scenario Configurations 5-7

Table 5-5: Scenario 1, Model Results 5-8

Table 5-6: Scenario 2, Model Results 5-9

Table 5-7: Scenario 3, Model Results 5-10

Table 5-8: Scenario 4, Model Results 5-11

Table 5-9. Erie NWRF 2028 and 2038 Average Annual and Maximum Month Flows and Loads 5-39

Table 5-10. Summary of Expansions/Improvements Needed at Erie NWRF 5-41

Table 5-11. Total Anticipated Project Costs of Liquids Stream Expansion Alternatives 5-41

Figures

Figure 5-1: Aerial of the Town of Erie Northwest Water Reclamation Facility (NWRF) ... 5-2
Figure 5-2: Components of the Visual Hydraulics Model ... 5-6
Figure 5-3: Town of Erie NWRF Process Schematic ... 5-17
Figure 5-4: Erie NWRF Headworks Screen ... 5-19
Figure 5-5: Erie NWRF Influent Pumping ... 5-20
Figure 5-6: Erie NWRF IFAS and Grit System ... 5-21
Figure 5-7: Erie NWRF Grit System Alternative 1 ... 5-23
Figure 5-8: Erie NWRF Grit System Alternative 2 ... 5-24
Figure 5-9: Erie NWRF IFAS Alternative 1 ... 5-26
Figure 5-10: Erie NWRF IFAS Alternative 2 ... 5-27
Figure 5-11: Erie NWRF IFAS Alternative 3 ... 5-28
Figure 5-12: NWRF RAS/IR Pumping ... 5-30
Figure 5-13: Propeller Style In-Basin Pumps Example ... 5-31
Figure 5-14: IFAS Foam Mitigation ... 5-32
Figure 5-15: Erie NWRF Blowers ... 5-33
Figure 5-16: Erie NWRF Clarifiers ... 5-34
Figure 5-17: Erie NWRF Tertiary Filter Schematic ... 5-35
Figure 5-18: Erie NWRF Disc Filter Layout ... 5-36
Figure 5-19: Erie NWRF UV System ... 5-37

5 Liquid Stream Process Performance Evaluation and Alternatives Analysis

5.1 Introduction

The Town of Erie's (Town) Northwest Water Reclamation Facility (NWRF) was constructed and became operational in 2011 to replace the Town's aging and limited treatment capability South Water Reclamation Facility (SWRF). The newly constructed NWRF had a permitted capacity to treat 1.5 million gallons per day (MGD) and 3,233 lbs BOD/day. A revised discharge permit was issued by CDPHE on March 24, 2015 and it expired on January 31, 2016. The permit has been administratively extended for the past three years.

In 2014, the NWRF was beginning to reach its permitted capacity, and a Project Implementation Report was performed by Frachetti Engineering to determine options for near-term and long-term expansion. The wastewater master plan completed by Indigo Water Group LLC in 2013 was then updated in 2015 by Burns & McDonnell to incorporate the recommendations from the Project Implementation Report. The capacity of the NWRF was then reevaluated and modified in 2016 and 2017 to increase the maximum month hydraulic capacity to 1.95 MGD, and the treatment capacity to 5,233 lbs BOD/day. Improvements included the following:

- New sheaves and motors to increase the capacity of the influent and internal recycle/RAS pumps
- Addition of a second IR pump
- UV expansion
- Addition of a third blower
- Addition of airflow control valve actuators and control system
- Additional IFAS media to expand oxic capacity
- Addition of a liquid solids loadout facility
- Construction of a RAS control structure to better split flow to the bioreactor basins

The Town of Erie has been communicating with CDPHE in an effort to obtain a new permit with the revised hydraulic/treatment capacities established by the 2017 rerating improvements. However, due to rapid and sustained growth in the area, the NWRF is now operating at or above 80 percent of those hydraulic and treatment capacities, at a maximum month flow rate of 1.58 MGD and 4,893 lbs BOD/day. Therefore, CDPHE requires that Erie begin planning for expansion, regardless of when CDPHE issues the revised permit.

The NWRF has also been receiving significantly higher influent ammonia loads than the plant was originally designed for, which has affected the performance of their secondary treatment system. Additionally, the existing solids stabilization system has not been able to perform as designed, because the system is unable to produce a desirable Class A biosolids product, and lime handling and scaling issues persist. While the biosolids disposal method of landfilling has been working up to this point, it creates a risk to the

Town because it limits disposal options, and produces a dependency on the biosolids hauler. Solids handling is specifically addressed in Chapter 6.

This chapter provides a roadmap for determining the specific liquid stream improvements and upgrades required for the next 20 year planning window. Figure 5-1 provides an aerial image of the facility and the following sections describe the existing system capacity analysis and recommended improvements.

Figure 5-1: Aerial of the Town of Erie Northwest Water Reclamation Facility (NWRF)

5.2 Objectives and Purpose

This chapter presents a liquids stream capacity and condition analysis that will conclude with a set of improvement recommendations to accommodate future flows and loads. Goals of this evaluation include:

- Perform hydraulic analysis that models the NWRF's liquids stream treatment process, run the model under a number of flow scenarios, and identify hydraulically-limited components of the system.
- Evaluate the total and firm existing treatment and hydraulic capacities of the NWRF liquids stream processes.

  - o Liquids stream processes include influent pumping, headworks, IFAS basins, blowers, secondary clarifiers, UV disinfection, and tertiary filters

- Compare future flow and loading demands, provided in Chapter 3, to the rated capacity of the existing unit processes. Consider future equipment capacity required for flow demand, treatment requirements, and process redundancy. Identify capacity restrictions in the liquids stream unit processes, and determine when they will occur.
- Develop a set of recommended process expansions and improvements that are necessary to meet the anticipated influent flows and loads demands within a 20 year planning frame, as well as CDPHE Regulation 85 and 31 nutrient limits.
- Include recommendations for minor equipment/control revisions that will allow the plant to continue operation during planning and design.

The following sections provide a summary of the drivers related to the NWRF's liquid stream process expansion and improvements, as well as a summary of the 10 and 20 year flows and loads to be used in the hydraulic and process capacity analyses.

5.3 Summary of Drivers

The primary drivers behind evaluating the liquid stream process at the Town of Erie NWRF are two-fold: projected influent flows and loads over the next 20 years, and tighter effluent discharge regulations anticipated with the implementation of CDPHE Regulation 85 and Regulation 31. Future design year flows and loads at the plant are discussed in Chapter 3 and summarized in Section 5.4 of this chapter. Chapter 4 discusses the anticipated future permit limits and respective timelines associated with Regulations 85 and 31, as well as the requirements and benefits offered by Policy 17-1. Table 5-1 shows a summary of the requirements and benefits of Policy 17-1.

Table 5-1. Policy 17-1 Incentive Program Requirements

Parameter	Reg. 85	Incentive Target
Total Phosphorus Annual Median	≥1.0 mg/L	≤0.5 mg/L
Months Earned	0	12
Total Inorganic Nitrogen Annual Median	≥15 mg/L	≤7 mg/L
Months Earned	0	12

As described in Chapter 4, the purpose of Policy 17-1 to encourage facilities to reduce TP and TIN below Regulation 85 required limits and in exchange the facility will receive an extended compliance schedule. By reducing the TP and TIN effluent concentration early, a facility can receive a maximum of an additional 10 years on top of the 5 years typically provided to comply with new regulations. This can result in deferring compliance with Regulation 31 standards. The exact requirements of Regulation 85 and Regulation 31 are shown below in Table 5-2.

Table 5-2. Nutrient-Related Effluent Standards (Regulation 85) and In-Stream Nutrient Values (Regulation 31)		
Parameter	Regulation 85 (Effluent Standard)	Regulation 31 (Warm Water In-Stream Standard)
TP (mg-P/L)	1.0 [(1)]	0.17 [(1)]
TIN (mg-N/L)	15 [(1)]	NA
TN (mg-N/L)	NA	2.01 [(1,2)]
Attached Algae Chlorophyll a, milligrams per square meter (mg/m^2)	NA	150

[1] Running Annual Median: The median of all samples taken in the most recent 12 calendar months

[2] Determined as the sum of nitrate as N, nitrite as N, and ammonia as N

A significant goal of this Master Plan and consequent expansion project is to prepare the Town's NWRF such that the plant can successfully treat to these impending regulatory effluent standards. The plant's secondary treatment process has been evaluated for its existing and future capacity to meet these standards, and the results of this analysis are summarized in this chapter.

5.4 Summary of Design Year Flows and Loads

Chapter 3 provided a description of the methods used to obtain the projected flows and loads to the Erie NWRF. The influent flows and loads for the next 20 years will determine what expansions and improvements are required for the NWRF's liquid stream treatment process to meet hydraulic demand, and also provide the necessary level of treatment to satisfying upcoming regulatory effluent standards. HDR worked with the manufacturer of the Erie NWRF's IFAS treatment system, Veolia Water Tech, to evaluate the expansion measures necessary to treat these influent flows and loads to the effluent levels discussed previously in Section 5.3. Veolia then provided an estimate for the waste activated sludge flows from the expanded secondary treatment system, based on modelling. A summary of the influent flows and loads as well as the solids flow values for the ten and twenty year design frames are provided below in Table 5-3.

Table 5-3. Erie NWRF 2028 and 2038 Average Annual and Maximum Month Flows and Loads

Parameter	Influent Flow (MGD)	BOD Loading (lb/day)[a]	TSS Loading (lb/day)[b]	Ammonia Loading (lb/day)[c]	TP Loading (lb/day)[d]	WAS Production (lb/day)[e]
Current (2017) Values **Population: 24,234 people**						
Average Annual	1.43	3,568	3,509	430	227	4,579
Maximum Month	1.58	4,893	4,419	644	316	5,706
2028 Values **Population: 49,226 people**						
Average Annual	2.80	6,997	7,193	840	443	N/A
Maximum Month	3.03	9,376	9,709	1,114	618	11,700
2038 Values **Population: 80,184 people**						
Average Annual	4.56	11,398	11,717	1,368	722	N/A
Maximum Month	4.93	15,273	15,815	1,814	1,007	18,300

[a] Avg Annual BOD Concentration=0.142 lb/d/cap (or 300 mg/L), and Max Month BOD Concentration = 0.190 lb/d/cap (or 372 mg/L)
[b] Avg Annual TSS Concentration=309 mg/L, and Max Month TSS Concentration=386 mg/L
[c] Avg Annual Ammonia Concentration=36 mg/L, and Max Month Ammonia Concentration=44 mg/L
[d] Avg Annual TP Concentration=19 mg/L, and Max Month TP Concentration=25 mg/L
[e] Based on values provided by Kruger

In the following sections, each piece of equipment within the liquids stream treatment process and its corresponding design capacity is compared against the values provided above, in order to determine if the plant's existing liquids stream treatment system is adequately sized for the anticipated ten and twenty year flows and loads to the Erie NWRF, and to determine which equipment may need expansion or replacement within those time frames.

5.5 Hydraulic Analysis

A hydraulic analysis was performed on the liquid stream system of NWRF using the Visual Hydraulics© program. The model was used to simulate NWRF operating at the 2028 peak hour flow of 5.6 MGD. The goal of the evaluation was to determine if the proposed plant expansion could accommodate peak hour flow of 5.6 MGD. Two levels of failure were investigated for each scenario: a process control failure and a catastrophic failure. A process control failure occurs when a weir is flooded and the flow split between process trains is no longer controlled. A catastrophic failure occurs when a process overflows.

Volumes, dimensions, and elevations were determined from the record drawings for the 2012 “Town of Erie: North Water Reclamation Facility” Project and provided the basis for the evaluation. The hydraulic model was developed for the gravity portion of the plant, from the outfall upstream to the Grit Unit. Per the 2013 Town Of Erie Wastewater Utility Plan, the effluent discharge elevation used for the analysis is the 100-yr flood plain elevation of 4934.7 FT. The modeled Peak Hour flow rate in 2028 is 5.6 MGD, as described in Chapter 2 of this report. Figure 5-2 provides an example of the Visual Hydraulics model developed for the NWRF.

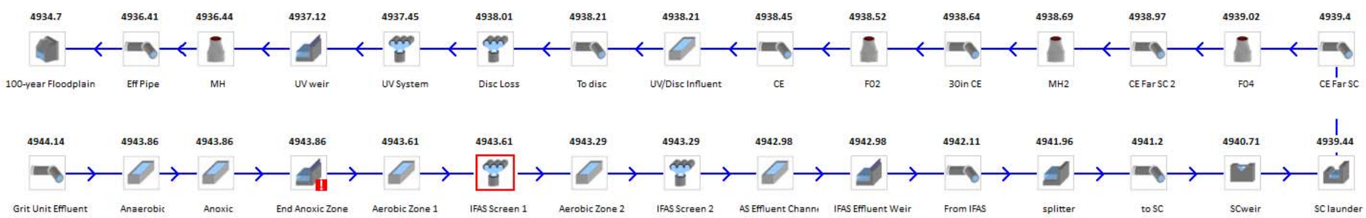


Figure 5-2: Components of the Visual Hydraulics Model

Types of processes that can be modeled include channels, weirs, special losses, flumes, pipes, and launders. An error icon appears when a flow measurement device is submerged. The water surface elevation for each icon was compared against record drawings to identify possible overflows.

5.5.1 Deviations from Existing Hydraulic Profile

The model was developed using the 2012 NWRF Hydraulic Profile as the primary source. Equipment as built drawings, O&M manuals, and vendor input were used in conjunction with hydraulic profile to develop the model. When comparing the as built drawings to the hydraulic profile two discrepancies were discovered:

- IFAS Effluent Weir Invert Elevation
  - 4942.50 on Hydraulic Profile
  - 4941.42 on Structural Drawings
  - Absent from Process Drawings
- Secondary Clarifier Splitter Weir Invert Elevation
  - 4941.13 on Hydraulic Profile
  - Weir gate with minimum elevation of 4941.33 on structural and process drawings.

Of the two discrepancies, the IFAS Weir Invert Elevation was the most concerning. The difference in weir elevation between the hydraulic profile and the as built drawings is 13 inches. Since overflowing basins was the primary concern with this exercise, the higher elevation of 4942.50 was used in this model.

For the Secondary Clarifier Splitter Weir, the as built drawing elevation of 4941.33 was used. The record drawings show that the weir gate cannot be lowered to the 4941.13 elevation, so the weir was modeled at its minimum elevation of 4941.33.

It is recommended that both of these discrepancies be field verified before final design.

5.5.2 Future Build-Out

The hydraulic model represents the next phase of build-out for the NWRF. The main process change is an addition of a third IFAS train. During normal operation, this train will treat a third of the plant influent flow, and will handle up to half of the influent if one of the other IFAS trains is offline.

Another change occurring with the build-out involves the anaerobic zone influent. Currently, each anaerobic zone is designed to be fed from the grit unit via a 12-inch line. Telescoping valves are intended to control this flow split. However, plant operators observed that the 12-inch lines are not large enough to pass the required flow. The grit unit's water surface elevation rises in response and ultimately overflows via weir into the second pass of the anaerobic zone – this creates a short circuit that circumvents half of the Anaerobic Zone and is detrimental to water quality. The proposed solution is replacing the 12" line and telescoping valve with a 16" line and plug valve. Instead of using the telescoping valve the control the flow split, the flow split will rely on the symmetrical geometry of each IFAS train.

5.5.3 Process Scenario Configurations

Five distinct NWRF scenarios were modeled. Four of the scenarios were initially modeled at the 5.6 MGD peak hour flow, a RAS rate of 2.25 MGD, and a ML recycle rate of 2.63 MGD. A fifth scenario was modeled around the 2038 build-out and peak hour flow. If the model showed failures, flows were then reduced to calculate the points where each of the failures is eliminated. Table 5-1 shows the process configurations of each scenario.

Table 5-4: Hydraulic Model Scenario Configurations

Scenario	Process Configuration			
	No. of IFAS Trains Online	No. of Secondary Clarifiers Online	Disc Filter Online	UV System Online
Scenario 1: All Processes Online	3	2	1	1
Scenario 2: One IFAS Train Offline	2	2	1	1
Scenario 3: One Clarifier Offline	3	1	1	1
Scenario 4, One Clarifier Offline & One IFAS Offline	2	1	1	1
Scenario 5, 2038 Build-Out	4	3	2	2

5.5.4 Scenario 1 – Three IFAS Trains and Two Secondary Clarifiers

Scenario 1 assumes all three IFAS trains (two existing and one future), both secondary clarifiers, the disc filter, and the UV system are all online and processing the full 5.6 MGD peak hour flow. In addition to the forward flow, a RAS Flow of 2.25 MGD, and ML Recycle of 2.63 MGD were assumed. The results are shown in Table 5-5.

Table 5-5: Scenario 1, Model Results

Location in Profile	Model WSE (Feet)	Available Freeboard (Feet)	Weir Downstream WSE (Feet)	Weir Fall (Inches)
Grit Unit	4944.11	3.22	N/A	N/A
Anaerobic & Anoxic Zones	4943.83	2.50	N/A	N/A
Anoxic Zone Weir	4943.83	2.50	4943.31	2.28
Aerobic Basin 1	4943.31	3.02	N/A	N/A
Aerobic Basin 2	4943.15	3.18	N/A	N/A
IFAS Effluent Weir	4942.98	3.35	4942.11	4.68
Splitter Structure Weir	4941.96	2.54	4941.20	1.56
Secondary Clarifier Launder Weir	4940.71	3.29	4940.03	6.84
Secondary Clarifier Launder	4940.03	3.97	N/A	N/A
UV/Filter Influent Channel	4938.82	1.18	N/A	N/A
Disc Filter	4938.62	1.38	N/A	N/A
UV Unit	4937.45	2.55	N/A	N/A
UV Effluent Weir	4937.12	2.88	4936.44	6.72

The results of Scenario 1 show that there is no risk of overflowing a process at peak hour flow as long as all trains are online. The short weir fall over the Anoxic Zone Weir (2.28-inches) and Secondary Clarifier Splitter Structure Weir (1.56-inches) mean that the weirs are close to being flooded and unequal flow splits could occur.

5.5.5 Scenario 2 – Two IFAS Trains and Two Secondary Clarifiers

Scenario 2 assumes two of the three IFAS trains, both secondary clarifiers, the disc filter, and the UV system are online and processing the full 5.6 MGD peak hour flow. In addition to the forward flow, a RAS Flow of 2.25 MGD, and ML Recycle of 2.63 MGD were assumed. The results are shown in Table 5-6.

Table 5-6: Scenario 2, Model Results

Location in Profile	Model WSE (Feet)	Available Freeboard (Feet)	Weir Downstream WSE (Feet)	Weir Fall (Inches)
Grit Unit	4944.56	2.77	N/A	N/A
Anaerobic & Anoxic Zones	4943.97	2.36	N/A	N/A
Anoxic Zone Weir	4943.97	2.36	4943.62	-1.44
Aerobic Basin 1	4943.62	2.71	N/A	N/A
Aerobic Basin 2	4943.16	3.17	N/A	N/A
IFAS Effluent Weir	4943.12	3.21	4942.12	4.56
Splitter Structure Weir	4941.96	2.54	4941.20	1.56
Secondary Clarifier Launder Weir	4940.71	3.29	4940.03	6.84
Secondary Clarifier Launder	4940.03	3.97	N/A	N/A
UV/Filter Influent Channel	4938.82	1.18	N/A	N/A
Disc Filter	4938.82	1.18	N/A	N/A
UV Unit	4937.45	2.55	N/A	N/A
UV Effluent Weir	4937.12	2.88	4936.44	6.72

In Scenario 2, the results show that there is little to no risk of a process overflow.

However, unlike Scenario 1 where three IFAS trains are in service, the two IFAS trains do not provide enough capacity to avoid flooded weirs. The weir separating the anoxic zone is completely flooded at peak hour flow. Unequal flow splits between the two remaining IFAS basins is a possibility as the head loss through each Aerobic Basin's media strainers might not be uniform.

Two solutions to the submerged Anoxic Zone Weir were successfully modeled. Reducing either the 2.25 MGD RAS rate or 2.63 ML recycle rate to zero allowed for minimal free discharge over the weir, approximately one inch. Temporarily eliminating all recycle flows provided 3 inches of free discharge.

5.5.6 Scenario 3 – Three IFAS Trains and One Secondary Clarifier

Scenario 3 assumes all three IFAS trains, one of the two secondary clarifiers, the disc filter, and the UV system are online and processing the full 5.6 MGD peak hour flow. In addition to the forward flow, a RAS Flow of 2.25 MGD, and ML Recycle of 2.63 MGD were assumed. The results are shown in Table 5-7.

Table 5-7: Scenario 3, Model Results

Location in Profile	Model WSE (Feet)	Available Freeboard (Feet)	Weir Downstream WSE (Feet)	Weir Fall (Inches)
Grit Unit	4944.64	2.69	N/A	N/A
Anaerobic & Anoxic Zones	4944.36	1.97	N/A	N/A
Anoxic Zone Weir	4944.36	1.97	4944.33	-9.96
Aerobic Basin 1	4944.33	2.00	N/A	N/A
Aerobic Basin 2	4944.16	2.17	N/A	N/A
IFAS Effluent Weir	4943.99	2.34	4943.96	-17.52
Splitter Structure Weir	4943.82	0.68	4943.76	-29.16
Secondary Clarifier Launder Weir	4941.85	2.15	4941.84	-14.88
Secondary Clarifier Launder	4941.84	2.16	N/A	N/A
UV/Filter Influent Channel	4938.82	1.18	N/A	N/A
Disc Filter	4938.62	1.38	N/A	N/A
UV Unit	4937.45	2.55	N/A	N/A
UV Effluent Weir	4937.12	2.88	4936.44	6.72

Scenario 3 sends the entire 5.6 MGD of influent and 2.25 MGD of RAS to a single Secondary Clarifier. This scenario shows the available freeboard within the Secondary Clarifier Splitter Structure shrinking to approximately 8 inches – an unacceptably close margin that risks overflow.

In addition to the overflow risk, four weirs were found to be completely submerged. Hydraulically, there is no break in head from the Grit Unit through to the UV system's effluent weir. Weir submergences range from 10-inches in the Anoxic Zone, to 29-inches at the Secondary Clarifier Splitter Structure.

As was done in Scenario 2's model, flow rates were adjusted to determine operational solutions to the issues of flooding and weir submergence. Eliminating the RAS and ML recycle flows reduced the risk of overflow in the Secondary Clarifier Splitter Structure by adding an additional foot of freeboard. Yet, even with without recycle flows, three weirs are completely submerged (with a 2-inch gap being added after the Anoxic Zone Effluent Weir. In order to maintain any free fall after all plant's weirs, no more than a combined 4.2 MGD can be sent to a single clarifier – this includes forward flow and RAS.

5.5.7 Scenario 4 – Two IFAS Trains and One Secondary Clarifier

Scenario 4 assumes two of the three IFAS trains, one of the two secondary clarifiers, the disc filter, and the UV system are online and processing the full 5.6 MGD peak hour flow. In addition to the forward flow, a RAS Flow of 2.25 MGD, and ML Recycle of 2.63 MGD were assumed. The results are shown in table 5-8.

Table 5-8: Scenario 4, Model Results

Location in Profile	Model WSE (Feet)	Available Freeboard (Feet)	Weir Downstream WSE (Feet)	Weir Fall (Inches)
Grit Unit	4945.29	2.04	N/A	N/A
Anaerobic & Anoxic Zones	4944.70	1.63	N/A	N/A
Anoxic Zone Weir	4944.70	1.63	4944.67	-14.04
Aerobic Basin 1	4944.67	1.66	N/A	N/A
Aerobic Basin 2	4944.42	1.91	N/A	N/A
IFAS Effluent Weir	4944.17	2.16	4944.13	-19.56
Splitter Structure Weir	4943.82	0.68	4943.76	-29.16
Secondary Clarifier Launder Weir	4941.85	2.15	4941.84	-14.88
Secondary Clarifier Launder	4941.84	2.16	N/A	N/A
UV/Filter Influent Channel	4938.82	1.18	N/A	N/A
Disc Filter	4938.62	1.38	N/A	N/A
UV Unit	4937.45	2.55	N/A	N/A
UV Effluent Weir	4937.12	2.88	4936.44	6.72

Scenario 4 was modeled as a worst case scenario, each process train has a unit offline at peak hour flow.

The issues with scenario 4 are nearly identical to those in Scenario 3 with the exception of the Anoxic Zone Weir submergence increasing by 4-inches and the IFAS effluent weir submergence increasing by 2-inches.

Like Scenario 3, capping the combined flow going to the single secondary clarifier at 4.2 MGD served to un-submerge all weirs. This shows that the reduction in Secondary Clarifier capacity is far more detrimental than the reduction in IFAS capacity.

5.5.8 Scenario 5 – 2038 Build-Out

Unlike Scenarios 1 through 4, which model the 2028 peak-hour flow of 5.6 MGD, Scenario 5 models the 9.1 MGD 2038 peak-hour flow. The 2038 NWRF is assumed to have four identical IFAS trains, three secondary clarifiers, two disc filters, and two UV trains. In addition to the 9.1 MGD forward flow, a RAS rate of 4.93 MGD and a ML recycle rate of 19.72 MGD. Results of this model are shown in Table 5-9.

Table 5-9: Scenario 5, Model Results

Location in Profile	Model WSE (Feet)	Available Freeboard (Feet)	Weir Downstream WSE (Feet)	Weir Fall (Inches)
Grit Unit	4944.78	2.55	N/A	N/A
Anaerobic & Anoxic Zones	4944.39	1.94	N/A	N/A
Anoxic Zone Weir	4944.39	1.94	4944.24	-8.88
Aerobic Basin 1	4944.24	2.09	N/A	N/A
Aerobic Basin 2	4943.83	2.50	N/A	N/A
IFAS Effluent Weir	4943.42	2.91	4942.85	-4.20
Splitter Structure Weir	4942.06	2.44	4941.42	-1.08
Secondary Clarifier Launder Weir	4940.73	3.27	4940.60	0.00
Secondary Clarifier Launder	4940.60	3.40	N/A	N/A
UV/Filter Influent Channel	4938.52	1.48	N/A	N/A
Disc Filter	4938.39	1.61	N/A	N/A
UV Unit	4937.43	2.57	N/A	N/A
UV Effluent Weir	4937.16	2.84	4937.13	-1.56
Effluent Splitter Box	4936.93	2.07	4934.95*	18.60*

Though the 2038 peak hour flow is roughly double that of the 2028 peak hour flow, the additional IFAS Basin, Secondary Clarifier and Disc Filter make overflow much less likely. Throughout the NWRF hydraulic profile there was a minimum of 1.4 feet of freeboard. Process control failures still occurred as most weirs were shown to be submerged.

The key differences in Scenario 5 occur downstream of the UV Effluent Weir. When flow leaves the UV facility, it is sent to the Effluent Splitter Box via a 30-inch line. During normal operation, flow is then conveyed to the outfall by a 30-inch diameter and 3600-foot long Effluent Pipe. If the head loss in the Effluent line is too great, excess flow spills over a weir and is sent to the Storage Reservoir. The invert elevation of this diversion weir is 4936.50. During modeling it was determined that the head loss in the effluent pipe will push the WSE of the splitter box higher than the diversion weir — forcing a 70/30 flow split. 6.4 MGD would continue to the outfall, while 2.7 MGD is diverted to the storage reservoir. Assuming the 100-year floodplain elevation of 4934.7, sending some of the flow to the Storage Reservoir is unavoidable during a 2038 peak-hour event.

Like the other scenarios where process control failures occurred, recycle rates were manipulated to determine solutions. Reducing the RAS and ML recycle rates to zero prevented the submergence of all weirs with the exception of the Secondary Clarifier effluent weir and the UV Effluent Weir. These submergences can be avoided by diverting at least 3.1 MGD of UV effluent to the Storage Reservoir prior to the Effluent Splitter Box. If this is done, and recycle rates are reduced to 25% of their maximum, operators would be able to maintain complete control over the plant.

5.5.9 Summary

The Visual Hydraulics© model shows that when all processes are online, they can accommodate the peak hour flow of 5.6 MGD without risk of overflow or submerging weirs. With minimal process adjustments, the plant can comfortably accommodate 2028 peak hour flows with one of the three IFAS basins offline.

The Secondary Clarifiers are the hydraulic bottleneck for the NWRF. At 2028 peak hour flow, the loss of a Secondary Clarifier would the complete submergence of four weirs. This means that every process downstream of the Grit Unit and upstream of the UV Effluent weir would be hydraulically connected without an air gap. In addition to the loss of control, there would be a potential overflow risk at the Secondary Clarifier Splitter Structure. Reducing the recycle rates to zero would mitigate the overflow risk, but most of the weirs would remain flooded.

Even with IFAS and Secondary Clarifier capacity reduced, as shown in Scenario 4, there is no direct evidence that catastrophic overflow would occur at 2028 peak hour flows. In this worst case Scenario the available freeboard dipped to approximately 8-inches and all flow control was lost. Despite concerns associated with reduced capacity, the modeled plant was still able to hydraulically pass the 5.6 MGD peak hour flow.

In all scenarios it is recommended that RAS and ML recycle rates be reduced during the peak hour event. This will ensure that there is no risk of overflowing the Secondary Clarifier Splitter Structure as well as maintain flow control by avoiding submerged weirs.

5.6 Liquids Stream Process Capacity and Condition Analysis

The goal of the existing liquids stream capacity analysis is to generate a high-level liquids treatment equipment condition assessment, as well as a broad timeline of liquids treatment equipment replacement and/or expansion. To this end, the existing liquids treatment equipment capacities were evaluated for both firm and total capacity at 2028 and 2038 design years. Firm capacity is defined as the equipment capacity required to meet necessary flow demand and provide one standby unit for maintenance and downtime, and total capacity is defined as the capacity of all equipment without standby.

Once the equipment firm and total capacities were evaluated and compared to the 2028 firm capacity and 2038 total capacity requirements, each equipment piece in the solids treatment system was categorized into one of three priority tiers:

- Primary Priority: Equipment improvements or additions that are required to meet 2028 firm capacity. To meet 2028 firm capacity, the equipment capacity must meet its necessary flow demand, which is the 2028 design flow value provided in Table 5-3, while also having a separate unit available for standby.
- Secondary Priority: Equipment improvements or additions that are not strictly mandatory for the next phase of expansions at the NWRF, but that will be required prior to 2028, in order to meet 2028 firm capacity needs.
- Tertiary Priority: Equipment improvements or additions which can further provide redundancy or capacity, ease maintenance, increase robustness, reduce equipment downtime, reduce risk of permit violations, and reduce emergency overnight work.

This analysis resulted in a categorized list of improvements or expansions required at the Erie NWRF, and a rough timeline for these recommended improvements. A summary of the liquids system capacity analysis, as well as the recommended timeline of improvements, is provided in Section 5.9.

5.6.1 Existing Facility Description

The liquids stream treatment process at the Erie NWRF consists of headworks and grit handling, followed by an integrated fixed filmed activated sludge (IFAS) secondary treatment process. This system uses a three-step biological process in which wastewater enters the two anaerobic zones in a parallel operation scheme, then flows to the anoxic zones, and is finally sent to the four aerobic zones. The existing aerobic zones have carrier media, which are small polyethylene fragments with a high surface area on which biomass is attached. This media reduces hydraulic retention time requirements in the reactors, allowing for smaller footprint requirements of the whole system. The internal recycle stream is pulled from directly downstream of the aerobic basins, from the splitter structure, and sent to the anoxic zones, and return activated sludge (RAS) is pulled from the secondary clarifiers and sent to the anaerobic zones. Further detail regarding the IFAS system is provided in Section 5.6.5.

After wastewater is passed through the IFAS system, it flows to the plant's two existing secondary clarifiers via a splitter structure. From the secondary clarifiers, flow can be sent either to a disc filter, and then to the UV system, or directly to the UV system. The

NWRF is required to process flow through the disc filter when discharging to the reuse storage ponds, but not when discharging to Boulder Creek. However, staff have indicated that flow is always sent to the disc filter upstream of the UV system, regardless of which discharge is used.

A process schematic of the entire Erie NWRF is shown in Figure 5-3, with the liquids stream process indicated by the red box. The following sections provide further detail regarding each unit process, including its overall purpose, condition, and capacity limitations with respect to future design flows and loads.

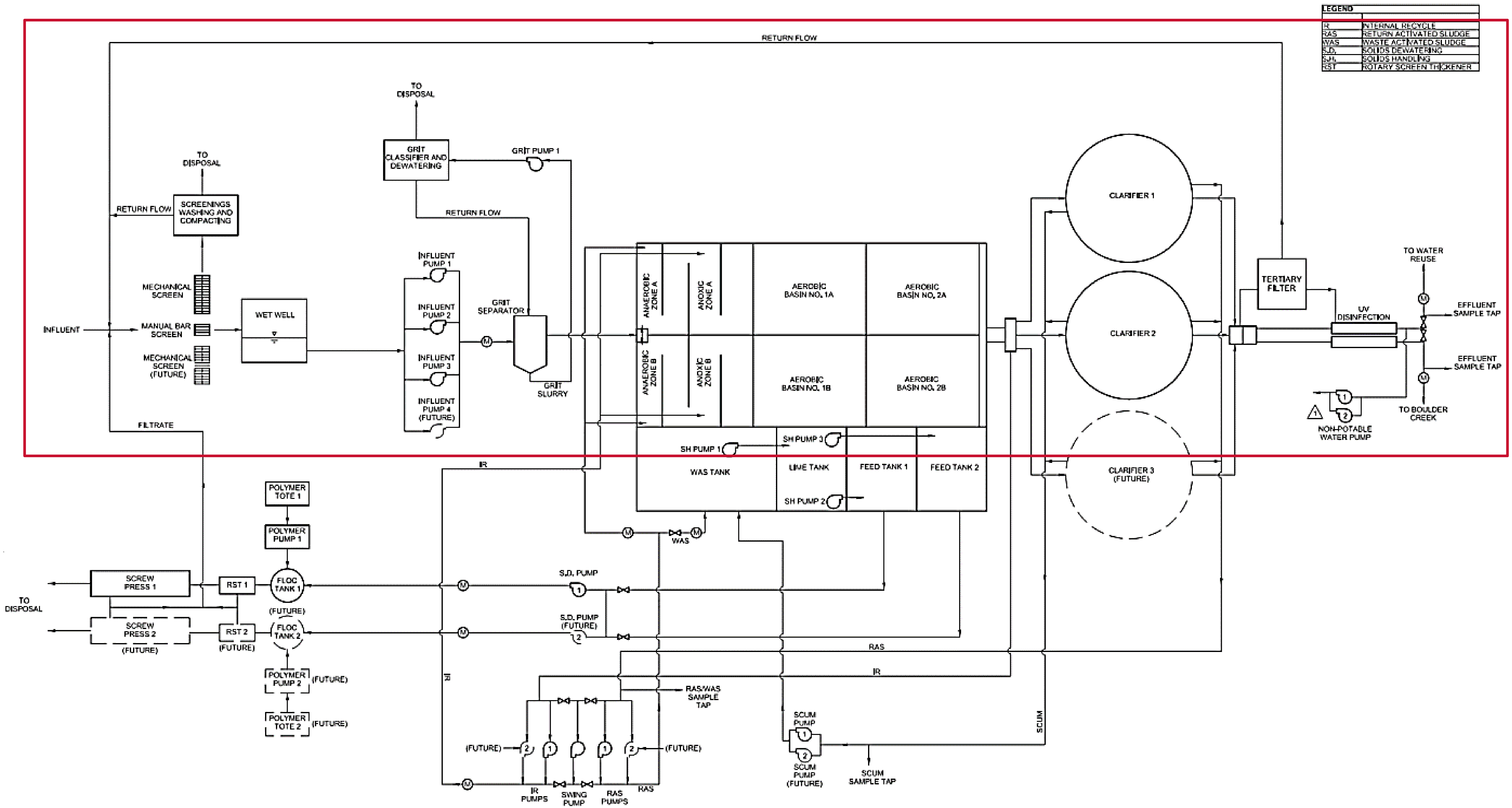


Figure 5-3: Town of Erie NWRF Process Schematic

This page is intentionally left blank.

5.6.2 Headworks

The NWRF's influent flow is directed to an MBS Bandscreen Monster headworks mechanical screen. (See Figure 5-4). There are three influent channels, but only one has a mechanical screen installed. Another channel has a manual bar screen installed in case the mechanical screen needs to be taken offline. However, using the manual bar screen for extended periods of time is undesirable due to the considerable operation and maintenance requirements, since the screen must be manually cleaned on a regular basis in order to remain operable. The third channel has no screen installed but is available for future expansion.

The mechanical screen is approximately 2.5 ft wide and nearly 6 ft deep, and its maximum capacity is 4.3 MGD. Since the 2028 design maximum month flow is 3.03 MGD, the mechanical screen meets the total capacity requirements for 2028. It does not technically meet 2028 firm capacity requirements, since there is no redundant mechanical screen. However, the manual bar screen can be used when the mechanical screen is offline.

Figure 5-4: Erie NWRF Headworks Screen

Since the 2038 design maximum month flow is 4.93 MGD, the mechanical screen does not meet total or firm capacity, and thus a second mechanical screen would be required prior to 2038. However, for the next phase of improvements at the NWRF to achieve 2028 design flow and treatment demands, HDR recommends that a second headworks mechanical screen be classified as a tertiary priority.

5.6.3 Influent Pumping

From headworks, wastewater is sent to the wetwell, and then pumped via influent pumps to the grit handling system. There are three influent Gorman-Rupp pumps installed at the NWRF. Each pump has a capacity of 2.31 MGD at 25.6 ft head, 79% efficiency, and 6.37 ft net positive suction head required (NPSHr). The total capacity of the influent pumps without accounting for redundancy is 6.93 MGD, and the firm capacity of the influent pumps is 4.62 MGD, which allows for one pump to act as a standby unit. Figure 5-5 shows the current configuration of the three influent pumps, with arbitrary numbers assigned to each existing and future pump.

Figure 5-5: Erie NWRF Influent Pumping

The 2028 maximum month influent flow is 3.03 MGD, meaning the influent pumps have the firm capacity required for 2028. However, changes to influent pumping will be required in order to provide the necessary improvements to the plant's IFAS system, which are discussed in Section 5.6.5. IFAS expansion will require splitting flow to route it to both the existing two IFAS trains, as well as a third new IFAS train. To split flow to three IFAS basins, the NWRF will first require a flow meter in the manhole upstream of the influent pumps to measure total flow, which then can used to determine the flow to each online basin. This flow split can be biased with the wetwell level indicator to prevent overflow. To tie into the influent pumps and direct flow to the future third and fourth basins, the plant must bypass pump during construction, and install a tee and flow meter at the spool upstream of Influent Pump 2, install the Influent Pump 3, and use Influent Pumps 3 and 4 for the plant's two existing IFAS basins, and Influent Pumps 1 and 2 for the two future IFAS basins. Additionally, a valve must be installed on the main header between Influent Pump 2 and Influent Pump 3, in order to isolate flows to each set of basins.

To accommodate necessary changes required for the IFAS process, discussed further in Section 5.6.5, HDR recommends that the alterations described above for the influent pumps are classified as a primary priority, and are performed as part of the NWRF's next expansion project. With four pumps installed, the firm influent pumping capacity is 6.93 MGD, which meets the firm capacity demands for 2028 and 2038.

5.6.4 Grit Handling System

The NWRF's current grit handling system consists of a grit separator chamber, grit classifier/dewatering unit, and a grit pump. The grit chamber and classifier are manufactured by Hydro International Wastewater, and the grit pump is manufactured by Gorman-Rupp. The maximum capacity of the grit chamber is approximately 4.2 MGD, the capacity of the grit classifier is 200 gpm, and the maximum capacity of the grit pump is 314 gpm. The existing grit handling system processes flow from the influent pumps prior to the two IFAS trains. Figure 5-6 below shows an aerial of NWRF's existing grit chamber, which is located between the IFAS trains at the south end of the basins.

Figure 5-6: Erie NWRF IFAS and Grit System

Although the plant's grit handling system meets 2028 total capacity requirements, there is no redundancy within the system. Furthermore, similar to the influent pumping system, changes that are needed for the IFAS system and discussed further in Section 5.6.5 will necessitate changes to the grit handling system. There is no existing method to tie the existing grit chamber into a third or fourth IFAS chamber. Therefore, there are two possible pathways to provide grit handling for the third IFAS train: modify the existing grit handling system to provide flows to all three trains, or install a new grit handling system for the third and fourth IFAS trains.

In order to modify the existing grit handling system to accommodate a third IFAS train, an additional telescoping valve must be installed in the grit chamber, and new influent piping would be routed through the walls of the easternmost basin to the new IFAS train. Figure 5-7 below shows a rough sketch of this layout alternative. This alternative provides a maximum grit system capacity of 4.2 MGD, and no process redundancy; therefore, this alternative meets 2028 total capacity requirements, but it does not meet 2028 firm capacity or 2038 total capacity requirements. Additional improvements would be required to make the grit piping and telescoping valves entirely functional, and are discussed in detail at the end of this section.

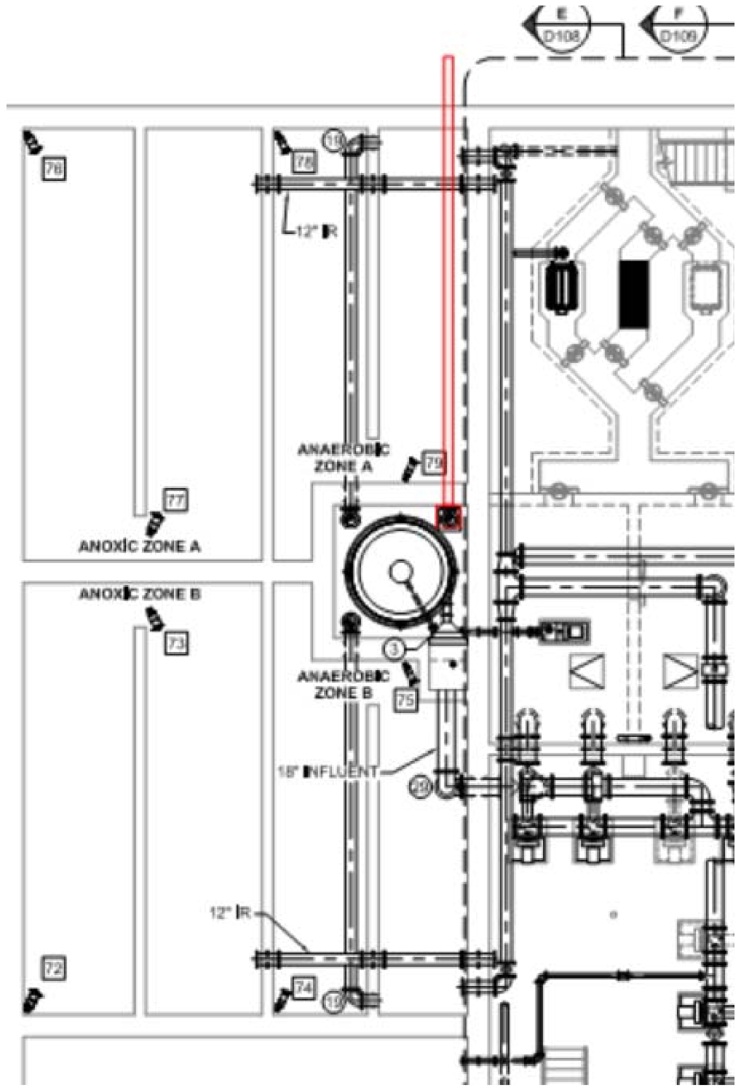


Figure 5-7: Erie NWRF Grit System Alternative 1

Advantages of this alternative are that it delays the need for a new grit handling system, which produces a lower capital cost for the liquids stream improvements. Additionally, this alternative avoids the need to pump grit back to disposal, since both the headworks screenings and grit dumpsters are located in the process building next to the existing IFAS trains. However, there are a number of disadvantages associated with this grit system layout alternative: it does not provide process redundancy, as mentioned above, and it limits the grit system capacity to that of the existing system. This alternative also introduces some design uncertainties. For example, the third and fourth telescoping valves may not fit in the existing grit chamber. Also, splitting flow evenly between three basins would be much more difficult for a number of reasons: the influent pipe lengths would not be equal for all three basins, the functionality of the two existing grit weirs and slide gates that also feed the two existing IFAS trains is not available for the third IFAS train, and the influent pumps could not be dedicated to particular basins.

The second grit system layout alternative is to install a new grit chamber with the additional of a third IFAS train. The new grit chamber would be located between the third and future fourth IFAS trains, similar to the existing system layout. In order to avoid building expansion, this alternative would involve pumping grit back to the plant's existing grit classifier. However, the grit chamber must be placed strategically so that grit can be pumped to the existing grit classifier, and influent can be pumped to the second grit chamber as shown in Figure 5-8 below, without interfering with the NWRF's main influent line, indicated in blue below. The second grit handling chamber would be sized to process 4.93 MGD, which is the 2038 expected maximum month flow, so that when the fourth IFAS train is installed for 2038 flow demands, the second grit chamber would need no alternations.

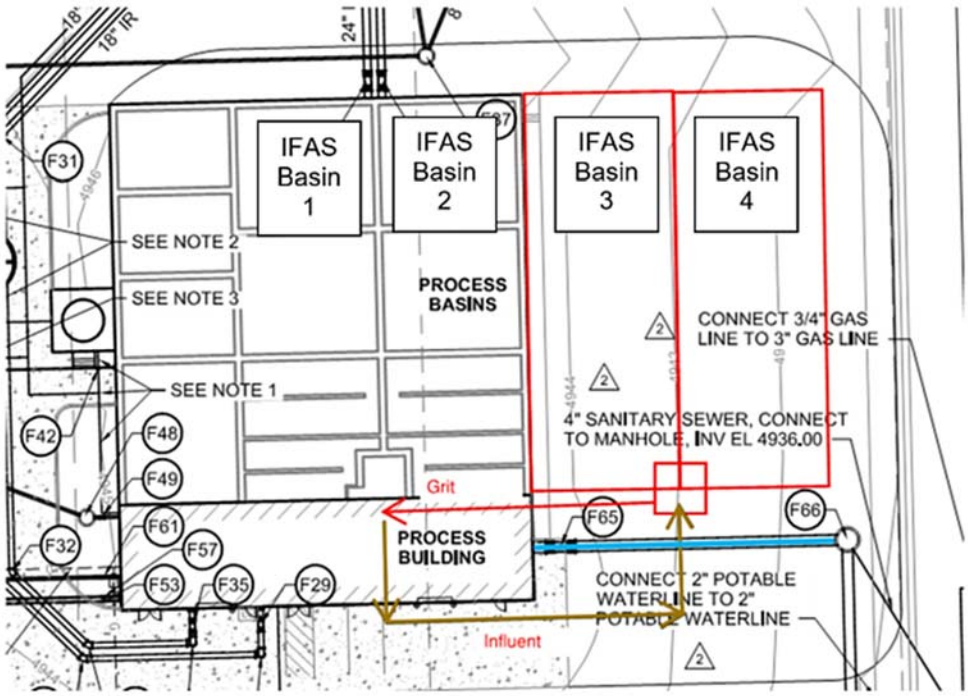


Figure 5-8: Erie NWRF Grit System Alternative 2

The advantages of this alternative are that it provides process redundancy, as well as the required firm capacity for 2028 design conditions. The existing grit chamber can be altered to provide a higher capacity by expanding the number of trays it has. Once this is completed, the two grit handling systems would also be capable of meeting 2038 firm capacity requirements. Lastly, this layout provides a more straightforward operation scheme than the previous alternative, since it allows flow to be split evenly among all IFAS trains.

The disadvantages associated with this alternative are that it requires a higher capital cost, as well as a longer grit piping run back to the plant's existing grit classifier/dewaterer.

Based on the relative pros and cons of each of the two grit system layout alternatives discussed, HDR recommends that a second grit system to be installed with the third IFAS train in the second layout alternative be classified as a primary priority for the 2028 expansion.

In addition to the second grit chamber, HDR recommends that modifications are made to the NWRF's existing grit handling system to optimize its performance. NWRF staff have informed HDR that the telescoping valves that feed influent to the two IFAS trains typically remain closed, due to difficulties in splitting flow between the two basins caused by significant headlosses in these pipes. Therefore, influent flows over the grit weir, and the two slide gates remain open. However, this operation scheme causes short-circuiting in the process, since the first stretch of the anaerobic zone is not fed directly. This in turn causes incomplete biological degradation and too short of a retention time in the anaerobic zone, and foaming in the aerobic zones. In order to remedy this issue, the influent pipes must be upsized to prevent significant headloss. As discussed in Section 5.5, HDR recommends that the IFAS process feed pipe from both of the grit chambers must be at least 16 inches in diameter.

5.6.5 Integrated Fixed Film Activated Sludge (IFAS) Process

As mentioned previously, the Erie NWRF uses an IFAS secondary treatment process to meet their current permitted effluent standards. However, the existing system is approaching maximum capacity. Each IFAS train was designed to be capable of processing a maximum month influent flow of up to 1.5 MGD per IFAS train, as stated by the 2012 original NWRF plant drawings by Burns & McDonnell. However, this capacity value was reduced to 1.43 MGD in an email dated February 2014 that was included in Appendix B of the Project Implementation Report completed by Frachetti Engineering in October of 2014.

Each of the two existing IFAS basins has four zones: the influent is sent from the grit chamber to the anaerobic zones, then to the anoxic zones, then to the aerobic zones, and lastly is discharged from the effluent channel. Currently, only the aerobic zones have carrier media, and at a 33 percent fill volume. In order to find the true capacity of the Town's existing IFAS process, HDR requested that Kruger provide a design capacity of the plant's existing system that is capable of processing current influent flows and loads to the design effluent standards discussed in Section 5.3. Namely, the NWRF's existing IFAS secondary treatment process must be capable of treating to the following effluent standards:

- Total Nitrogen (TN) < 10 mg/L
- Ammonium, measured as nitrogen (NH4-N) < 1 mg/L
- Total Phosphorus (TP) < 0.7 mg/L

Kruger stated that if the Town were to add additional media and post-anoxic volume in order to achieve the limits listed above, the existing two IFAS trains can process a total capacity of 2.46 MGD, meaning each IFAS train can process 1.23 MGD. This means the NWRF's existing IFAS system does not meet 2028 total or firm capacity, and IFAS process expansion is classified as a primary priority for the next expansion project.

IFAS Expansion Layout Alternative 1: New Basins with Swing Zone

There are a number of alternatives for expanding the Town's IFAS system. HDR evaluated three main alternative layouts for this expansion. The first layout alternative is to construct new treatment zones at the end of the two existing IFAS trains, and a new third IFAS train identical to the first two, with room for a fourth train in the future. A rough layout sketch for this alternative is provided in Figure 5-9. The blue lines indicate existing infrastructure, and the yellow lines indicate improvements that would be performed as part of the next expansion project at the plant, and that would be designed for 2028 conditions. The orange lines represent expansions that would be performed in the future, for 2038 conditions.

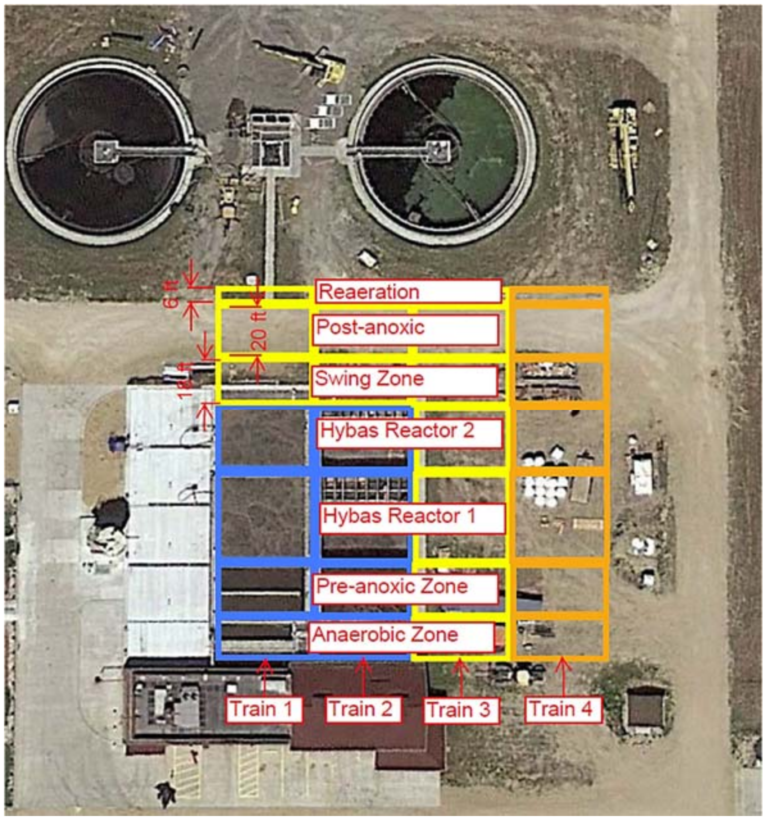


Figure 5-9: Erie NWRF IFAS Alternative 1

In this alternative, a “swing zone” would be installed on Trains 1 and 2 immediately after the existing Hybas (aeration) reactors. These swing zones would have pulsed aeration, and be filled to a 33 percent volume with Kruger’s K3 or K5 Heavy media, which is media that typically sinks to the bottom of the tank unless the tank is being aerated, at which point the media is lifted. The objective of this zone is to provide conservative treatment capacity via polishing and deoxygenating capabilities. This zone will essentially have the capacity to act as either an extension of the aeration zones, or as additional anoxic basin volume, depending on the influent characteristics and treatment needs. This will prevent the Town from having to fill all four aerobic basins with 50-55 percent media fill for 2038 design conditions, which may have negative effects on the IFAS equipment and operation. After the swing zone, a post-anoxic basin would be installed on both trains to help with denitrification, and prevent too much air from being recycled back to the pre-anoxic zone. A reaeration basin would also be added at the very end of each IFAS train to help improve the settleability of the sludge in the secondary clarifiers.

A third IFAS train that is identical to the first two IFAS trains described above would also be required for 2028 design conditions. In the future, for 2038 conditions, a fourth train identical to the first three would be added as well. For constructability, HDR would recommend that the third IFAS train is constructed to completion, and then that the third complete IFAS train process all flow while the improvements described above were implemented on IFAS Trains 1 and 2.

The advantages of this alternative are that the NWRF can use approximately 40 percent fill in all Hybas reactors at 2038 conditions, it has the highest level of treatment and operational flexibility of all alternatives, it maximizes use of the existing space between the IFAS basins and secondary clarifiers, and it provides necessary process redundancy. However, disadvantages of this alternative are that it requires new infrastructure, as well as piping and road relocation to accommodate new basin volume.

IFAS Expansion Layout Alternative 2: New Basins with Common Reactors

The second IFAS expansion layout alternative involves installing a third IFAS train identical to the existing IFAS Trains 1 and 2, leave space for a fourth IFAS train for 2038 conditions, and then constructing a single post-anoxic reactor for all four basins, followed by a single reaeration reactor for all four basins. Figure 5-10 below shows a rough layout of this alternative.

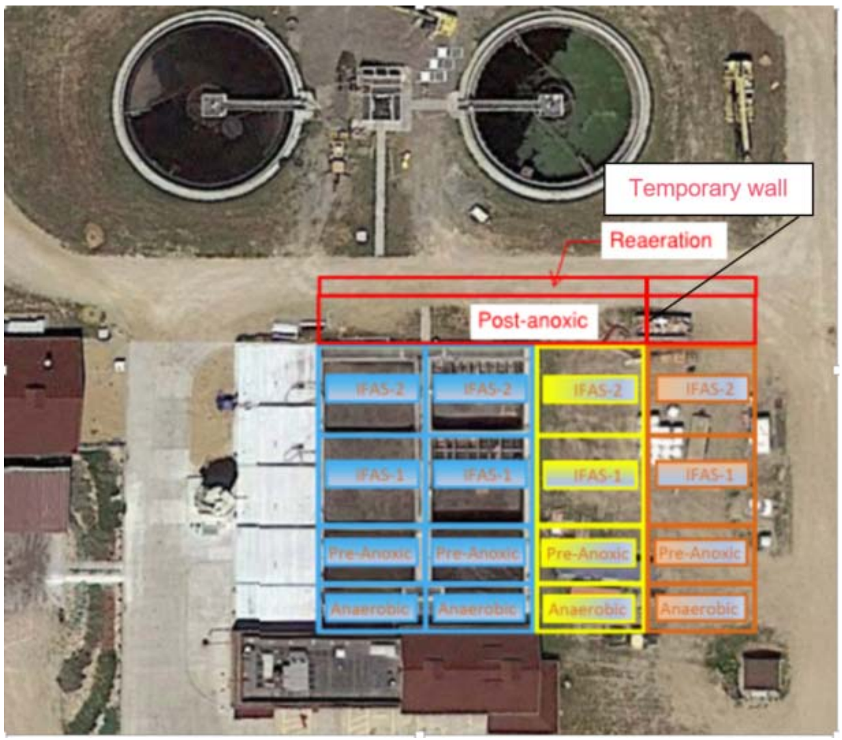


Figure 5-10: Erie NWRF IFAS Alternative 2

The advantages of this alternative are that it provides a homogenized effluent from the IFAS system to the secondary clarifiers, and requires less infrastructure and basin volume than required for the previous alternative. However, this alternative layout would require maximum media fill for 2038 design conditions, reduced redundancy and level of plant robustness for the post-anoxic and reaeration zones, requires complicated construction to build the 4th basin, and the new basin volume still requires road and piping relocation.

IFAS Expansion Layout Alternative 3: Repurpose Solids Storage Basins

The last IFAS expansion layout alternative is to install a third IFAS train identical to the two existing IFAS trains at the plant for 2028 conditions, and a fourth identical IFAS train for 2038 conditions. The existing WAS, lime, and feed tanks would be repurposed into basins for the post-anoxic and reaeration zones. Figure 5-11 below shows an aerial of this IFAS layout alternative.

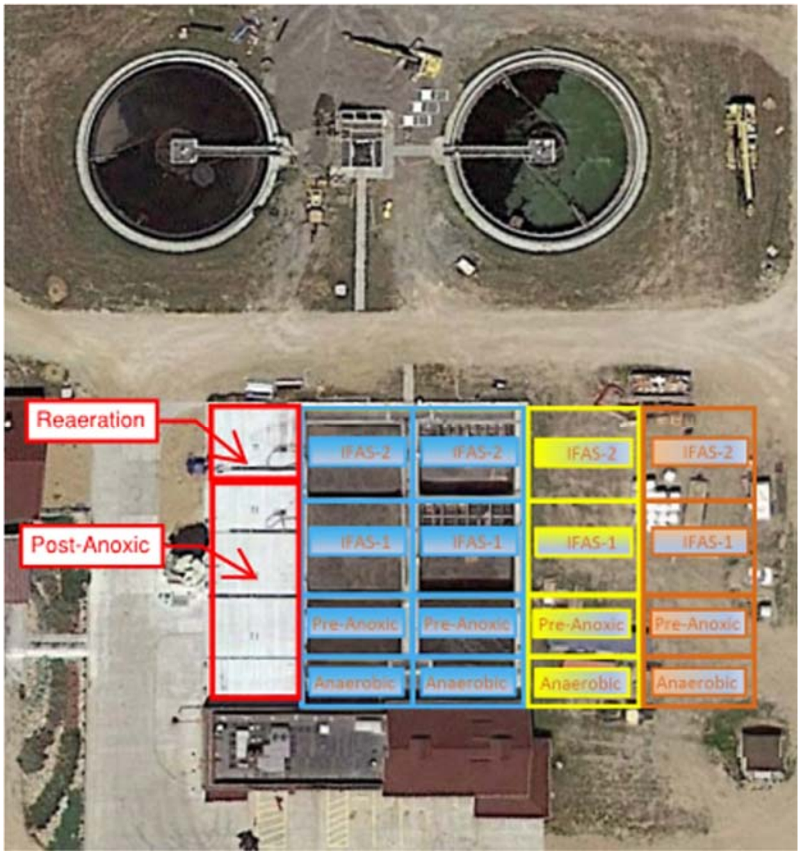


Figure 5-11: Erie NWRF IFAS Alternative 3

The WAS, lime, and feed storage tanks have a total volume of about 63,000 cubic feet. However, the total original volume of post-anoxic and reaeration tanks required is nearly 73,000 cubic feet combined. Therefore, this alternative does sacrifice some treatment capacity to accommodate reuse of existing infrastructure. Therefore, advantages of this alternative include reuse of existing infrastructure, as well as providing a homogenized effluent from the IFAS system to the secondary clarifiers. However, this alternative does not meet the 2038 design condition treatment goals, and it also would require maximum media fill for 2038 conditions. Additionally, there is no redundancy for the post-anoxic or reaeration zones without the additional of new walls inside the solids storage tanks. Lastly, this alternative has the most complex design in regards to piping; it requires a serpentine flow path for influent, introducing several sources of headloss.

Recommended IFAS Expansion Layout Alternative

HDR met with the Town of Erie staff to discuss all IFAS expansion layout alternatives. Based off of these discussions HDR recommends Alternative 1 for the necessary IFAS process improvements and expansions, in which new swing, post-anoxic, and reaeration basins are constructed on the existing IFAS trains, a third identical train is constructed for 2028 design conditions as part of the next expansion project, and a fourth identical train is constructed for 2038 design conditions in the future. This alternative is designed to meet all the effluent standards required to meet Policy 17-1, provides appropriate process redundancy, and offers the most operational flexibility and treatment capacity with the addition of the swing zone. An economic analysis of this layout alternative with a number of additional options is provided in Section 5.7.

Mixing Requirements

A number of ancillary processes and equipment needs for the IFAS system were also evaluated to ensure that their capacities and conditions were sufficient, and that the performance of the expanded IFAS system is optimized. For example, mixing can be introduced in the aeration zone to potentially reduce airflow requirements of the blowers. One common mixer type that is utilized in IFAS applications is a slow speed banana blade mixer. However, although addition of a banana blade mixer may reduce air requirements and keep media from settling or floating in the aeration zones, there are a few disadvantages to this equipment. A submerged mixer has more complex operation and maintenance needs compared to exposed equipment. Also, contact between the media and the submerged mixer will cause increased wear on both the IFAS carrier media and the mixer.

Another method for mixing the aeration zones is via in-basin pumping. As discussed further in the following section, the plant's existing IR/RAS pumps will not have the required capacity to meet the 2028 firm capacity needs. Therefore, those centrifugal pumps can be repurposed to process RAS flow only, and propeller-style in-basin pumps can be added in each IFAS train to provide internal recycle pumping from the aerobic zones to the pre-anoxic zones. These pumps would provide sufficient mixing in the aerobic zones, and provide the required IR pumping capacity and redundancy.

Internal Recycle/Return Activated Sludge/Swing Pumping

The Town currently has four Gorman-Rupp self-priming centrifugal pumps that are used for internal recycle (IR), waste activated sludge (WAS), and return activated sludge (RAS) pumping. (See Figure 5-12.) Two are used exclusively for IR pumping, one is used exclusively for RAS/WAS pumping, and the last is a “swing” pump that can be used for either IR or RAS/WAS pumping. All four pumps are identical, although the first three were installed in 2012, and the second IR pump was added in 2017. Each pump has a 2.13 MGD design capacity at 20 ft head, 79% efficiency, and 7 ft net positive suction head required (NPSHr). The total resultant capacity of all four pumps is 8.52 MGD.

Figure 5-12: NWRF RAS/IR Pumping

If the required RAS and IR rates, as suggested by Kruger, are 100% of influent flow for RAS, and 400% of influent flow for IR pumping, then the NWRF would need a total of five times the influent flow to meet both the RAS and IR required pumping capacity, and a small additional capacity for WAS pumping. This results in a 2028 firm capacity requirement of 15.25 MGD for all RAS/WAS/IR pumping. The existing IR/RAS pumps therefore do not meet 2028 firm or total capacity requirements. However, the previous section discussed converting all four RAS/IR pumps into just RAS/WAS pumps, and installing IR pumping in the IFAS basins with propeller style in-basin pumps. This allows the four existing centrifugal pumps to meet all 2028 and 2038 firm and total capacity requirements for RAS/WAS pumping. Figure 5-13 below shows an example of an application that uses propeller style in-basin pumps.

Figure 5-13: Propeller Style In-Basin Pumps Example

In order to meet 2038 maximum month internal recycle flow demand with 4 times the influent flow for IR flow, the NWRF will need nearly 19.71 MGD firm capacity for the propeller style in-basin pumps. Since each of the four IFAS basins will receive a quarter of the total influent flow, each basin must have 4.93 MGD firm capacity for IR pumping. However, this value may change if the IR rate is less than 400% of the influent flow. For example, if the IR rate is only 300% of the influent flow, then each IFAS train requires 3.7 MGD IR pumping capacity for 2038 conditions.

HDR recommends that propeller style in-basin pumps are installed for IR pumping with the IFAS expansion improvements performed as part of the NWRF's next expansion project, and that all four of the IR/RAS/WAS centrifugal pumps are converted to RAS/WAS only pumps. The IR pumps should be sized to a capacity that meets 2038 firm capacity requirements, and 400% of the influent flow.

Foam Mitigation

The NRWF's IFAS system has experienced fairly persistent foaming issues in the aerobic reactors in the last couple of years. This may be due to a number of factors including short-circuiting and insufficient retention time in the anaerobic zone, over-aeration in the aerobic zones, or a shift in influent/sludge characteristics. However, this issue must be remedied to prevent any potential for an overflow event. Although a few foam management methods exist, only a few are viable for implementation in IFAS systems. For example, there are a number of difficulties associated with using rotating skimmers or other surface wasting methods for managing foam: it can be difficult to prevent carrier media from escaping the basins, and the skimmer also should have dipping capability to be most effective. Figure 5-14 shows an application with surface wasting for foam mitigation.

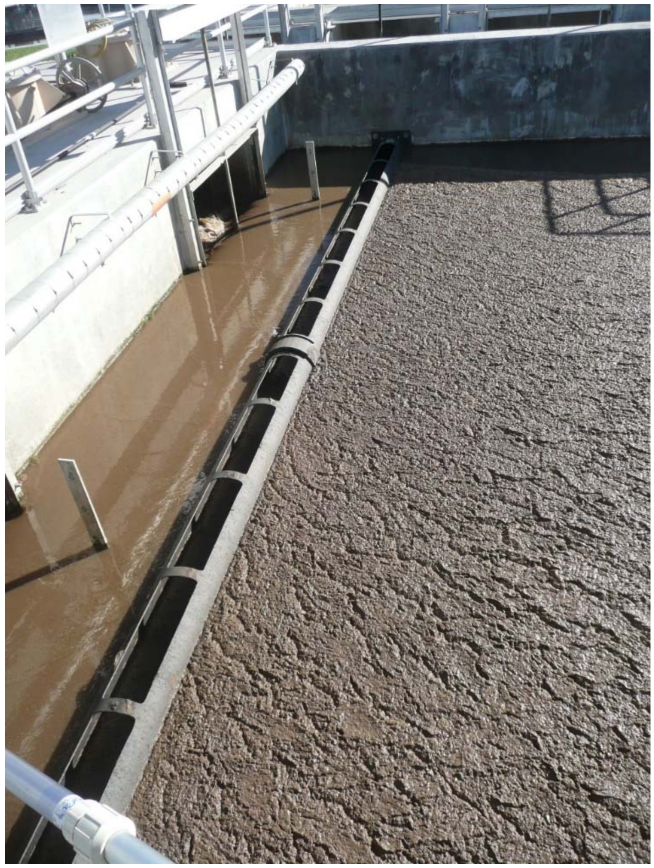


Figure 5-14: IFAS Foam Mitigation

The most viable solution is to use a downward opening gate in each basin, and send foam to the WAS stream. A spray bar would also be installed to “push” foam toward the gates. HDR recommends that downward opening gates for foam mitigation be included with all other IFAS expansion and improvement measures discussed in this section as part of the next expansion project.

5.6.6 Blowers

The Town of Erie’s existing blowers have been experiencing a number of issues that prevent them from performing as designed for the IFAS system. The NWRF has one Aerzen blower with a design capacity of 3885 scfm, and two K-Turbo blowers with a design capacity of 3496 scfm each. The total capacity of the system is 10,877 scfm. For the recommended 2028 IFAS expansion design, Kruger suggests that the IFAS system have an air capacity of 9500 scfm. Therefore, the plant’s existing blower capacities do not meet 2028 firm capacity requirements. The air capacity required for the 2038 expansion is 14000 scfm, meaning that the existing blower capacity also does not meet 2038 total capacity requirements. Figure 5-15 shows one of the K-Turbo blowers and the Aerzen blower.

Figure 5-15: Erie NWRF Blowers

Although the plant's existing blowers do not have the capacity to meet 2028 firm capacity requirements, the NWRF staff have indicated to HDR that the blowers are currently over-aerating their secondary treatment process, due to the turndown restrictions of the blowers. Adding more air capacity for the IFAS system at this time will not help the over-aeration issues the plant is experiencing. Therefore, HDR recommends that additional aeration capacity with appropriate turndown capabilities for the IFAS system is classified as a secondary priority; that is, another blower should be added prior to 2028, but not as part of the plant's next expansion project. This will allow the blower capacity to meet 2028 firm capacity conditions in the near future, but also postpones the expenses associated with acquiring additional aeration capacity while the plant is currently experiencing issues with over-aerating.

5.6.7 Clarifiers

The NWRF has two 70 ft diameter secondary clarifiers that receive effluent from the IFAS process, and send RAS back to the front of the IFAS process as well. These clarifiers each have a volume of 420,761 gallons, for a total volume of 841,522 gallons. Assuming a conservative surface loading rate of 1,000 gpd/ft^2, based on Chapter 70 of the "Ten States Recommended Standards for Wastewater Facilities," each clarifier is capable of processing up to nearly 3.8 MGD, giving a total capacity of 7.6 MGD. The clarifiers at the Erie NWRF are shown below in Figure 5-16.

Figure 5-16: Erie NWRF Clarifiers

Since the capacity of a single clarifier exceeds the 2028 design maximum month flow of 3.03 MGD, the clarifiers do meet 2028 firm capacity requirements. However, they do not meet 2038 firm capacity requirements with only two clarifiers. Therefore, appropriate space for third and fourth clarifiers north of the existing two clarifiers should be maintained. HDR recommends that no additional clarifier capacity is added as part of the plant's next expansion project, but that addition of a third clarifier be classified as a primary priority for the 2038 expansion project.

Plant staff have noted that the secondary clarifiers frequently show algae growth. There are two primary methods available to address this: clarifier covers, or chemical addition for algae control. HDR recommends that the Town test chemical addition for algae control, and if the results are unsuccessful, evaluate the possibility of covering the secondary clarifiers.

5.6.8 Disc Filter

The Erie NWRF currently has one disc filter that can accept effluent from the secondary clarifiers. The Town is required to use the disc filter upstream of the UV system when discharging to their reuse reservoirs; however, plant staff have informed HDR that they prefer to use their disc filter at all times, since it gives a conservative level of treatment that can provide flexibility at upstream processes. The disc filter is also manufactured by Kruger, and has a design capacity of 3.6 MGD. Since there is only one disc filter in place at the plant, it technically does not meet 2028 firm capacity requirements, although it does meet 2028 total capacity requirements.

Although the plant's existing disc filter does not meet 2028 firm capacity requirements, the need for a redundant disc filter can be avoided by discharging to the creek, instead of to the reuse reservoirs. Therefore, HDR recommends that a second disc filter be classified as a secondary priority for the 2028 expansion project. If another disc filter is installed, it must meet 2038 total capacity requirements of 4.93 MGD. A preliminary flow schematic of the new disc filter and UV system is shown below in Figure 5-17.

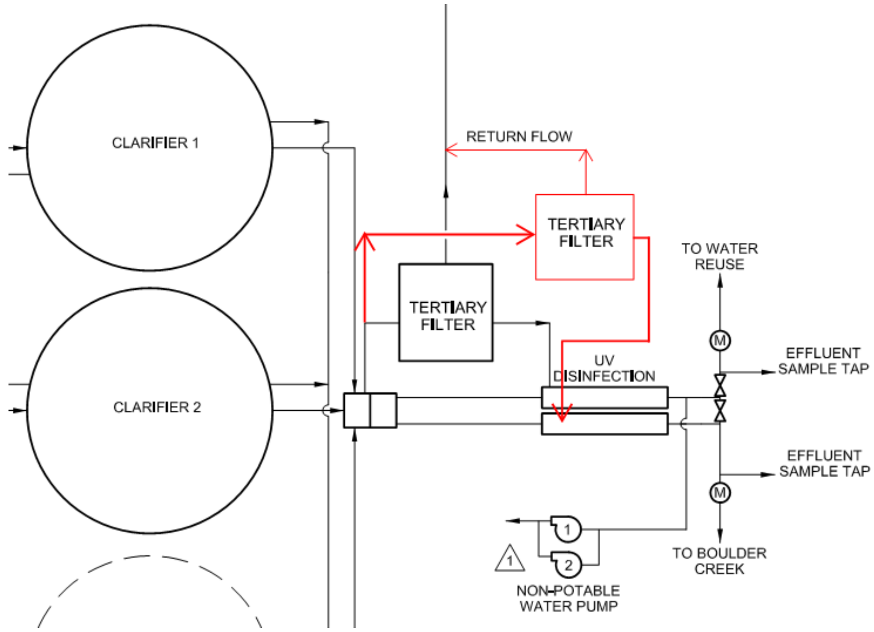


Figure 5-17: Erie NWRF Tertiary Filter Schematic

This arrangement allows the Town to either send clarifier effluent directly to the UV system, or to one or both disc filters. However, due to the existing layout of the disc filter and UV system, each disc filter would have to be assigned to one UV bank, meaning if one disc filter is taken offline and the other is in use, the UV bank corresponding to the disc filter in operation must be used as well. A preliminary layout of the second disc filter in the existing system is shown below in Figure 5-18.

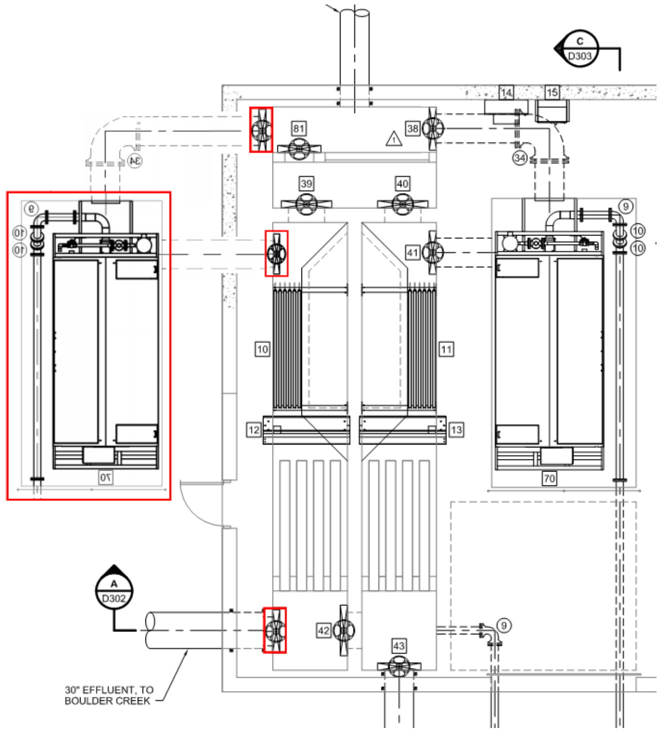


Figure 5-18: Erie NWRF Disc Filter Layout

The second disc filter would tie into the second UV bank, as shown. A number of slide gates would be added to facilitate these tie-ins. This layout shows the second disc filter located outside of the plant's existing UV/Dewatering Building. The Kruger disc filter can be altered to remain outdoors, and placing the second disc filter outside reduces the capital costs associated with installing a second disc filter. However, there are a number of advantages to locating the second disc filter indoors, including: no effects of cold weather on performance, no need to insulate equipment and piping, and fewer maintenance requirements.

HDR recommends, as stated earlier, that a second disc filter be classified as a tertiary priority for the plant's 2028 expansion project, and that the decision of whether to locate the second disc filter indoors or outdoors is determined during predesign.

5.6.9 UV System

The NWRF's existing UV system consists of two Trojan UV300Pluss UV banks. Each bank has a current peak design flow of 4.2 MGD, meaning their capacity meets 2028 firm capacity requirements. Figure 5-19 below shows the UV banks at the Erie NWRF.

Figure 5-19: Erie NWRF UV System

Although there are no expansion efforts required for the UV system, there are a few issues with the existing UV system that should be remedied as part of the next expansion project; for example, removing the plywood that is currently acting as a gate and installing slide gate in its place. The Town is currently replacing bulbs and performing improvements to one of the UV banks. After this work is complete, the capacity of both systems should be verified to ensure that 2028 firm capacity conditions are met. In the future, for expansion to 2038 conditions, the Town should evaluate the possibility of expanding the existing banks and adding bulbs, and re-rating the capacity of the system with Trojan's input. However, HDR recommends that no expansions or improvements are made to the existing UV as part of the 2028 expansion project.

5.6.10 Summary of Existing Liquids System Evaluation

A summary of the existing liquids treatment system capacity analysis is shown below in Table 5-9. The last two columns of the table state whether or not the capacity of the plant's existing system is capable of meeting 2028 firm capacity conditions and 2038 total capacity conditions. The results of this analysis determined how all expansions or improvements needed at the Erie NWRF are categorized into each tier of priorities.

Table 5-9. Erie NWRF 2028 and 2038 Average Annual and Maximum Month Flows and Loads				
Equipment Name	**Existing Capacity Per Unit**	**Existing Total Capacity**	**Meets 2028 Firm Capacity Needs?**	**Meets 2038 Total Capacity Needs?**
Headworks Mechanical Screen	4.3 MGD per channel	4.3 MGD	No [A]	No
Screenings Washer/Chute	4.3 MGD	4.3 MGD	No	No
Influent Pumps	2.31 MGD per pump	6.93 MGD	Yes	Yes
Grit Separator Chamber	4.2 MGD	4.2 MGD	No [B]	No
Grit Dewaterer (Grit Snail)	200 gpm, (4.2 MGD)	4.2 MGD	No	No
Grit Pump	314 gpm, (4.2 MGD)	4.2 MGD	No	No
Blowers	3496 scfm (2 units) and 3884.6 scfm (1 unit)	10,877 scfm	No	No
IFAS System	2.46 MGD	2.46 MGD	No	No
Clarifiers w/ mechanisms	3.8 MGD per clarifier	7.6 MGD	Yes [C]	Yes
IR/RAS/Swing Pumps	2.13 MGD per pump	8.52 MGD	No [D]	No [D]
Disc Filter	3.6 MGD peak flowrate	3.6 MGD	No	No
UV Banks	Avg flow = 1.2 mgd, Current peak flow = 4.2 mgd	8.4 MGD	Yes	Yes

[A] Manual screen provides additional standby capacity.

[B] Grit separator integral to IFAS – firm capacity not feasible.

[C] Capacity to be confirmed. Tertiary filter provides some safety factor.

[D] In existing configuration, there is not enough capacity to meet 2028 demands for IR/RAS flow.

This page is intentionally left blank.

Table 5-10 below provides the recommended categorization of expansions and improvements needed at the Erie NWRF, based on the existing liquids stream system capacity analysis. These recommendations and their respective categorizations are a culmination of the capacity analysis provided above, but they also incorporate input provided by the Town of Erie staff.

Table 5-10. Summary of Expansions/Improvements Needed at Erie NWRF

Primary Priority	Secondary Priority	Tertiary Priority
• 2nd Grit System • 3rd IFAS Basin • Addition of Anoxic and Re-aeration Zones on Each Basin • RAS/IR Separation • Addition of new IR in-basin pumps • Grit Pump • Fourth Influent Pump	• Aeration Capacity Addition with Blowers • Grit Dewaterer/Classifier	• Headworks Screen • 2nd Disc Filter[a]

[a] Indoor versus outdoor location to be determined during predesign, if this item is included in the NWRF's next expansion project.

The final recommendations for the NWRF's next expansion project for 2028 design conditions are provided in Section 5.9.

5.7 Cost Evaluation of Alternatives

Table 5-11 below provides a summary of the cost estimates for each of the narrowed liquids stream expansion alternatives.

Table 5-11. Total Anticipated Project Costs of Liquids Stream Expansion Alternatives

Alternative	Total Anticipated Project Cost (TAPC)
IFAS Expansion with Primary Priorities	$8,974,000
IFAS Expansion with Secondary Priorities	$10,086,000

IFAS Expansion with Tertiary Priorities (Expand Dewatering/UV Building)	$11,858,000
IFAS Expansion with Tertiary Priorities (No expansion of Dewatering/UV Building)	$11,702,000

Four liquids stream expansion alternatives were cost-estimated: IFAS expansion with primary priorities, IFAS expansion with primary and secondary priorities, IFAS expansion with primary, secondary, and tertiary priorities included, and the second disc filter located indoors, and lastly IFAS expansion with primary, secondary, and tertiary priorities included, and the disc filter located outdoors. The primary, secondary, and tertiary priorities are listed previously in Table 5-10.

5.8 Non-Economic Evaluation of Alternatives

A non-economic evaluation captures the criteria that are not associated with cost, but that are important for ensuring that the recommended improvements and expansions are implemented as seamlessly as possible at the NWRF. However, the liquids stream expansion alternatives are generally all variations of the same process and technologies. This makes a non-economic evaluation less applicable and of limited value for this chapter, because the alternatives differ only by the extent of expansions that the Town's budget will allow for.

This chapter did not evaluate various technologies for a new process; rather, it categorized improvements and expansions that are necessary within the next twenty years into three tiers of priority. This categorization ensured that redundancy was prioritized for the recommended expansions and improvements at the NWRF. By prioritizing redundancy and plant robustness, this evaluation of liquids stream expansion alternatives also captured risk, safety, ease of operations, and flexibility as well, which are all often criteria used in a non-economic evaluation. For the remaining criteria, such as operator familiarity, operator attention, implementability, and robustness, each alternative would be scored similarly, since they are each variations of the same process and technologies. Therefore, for these reasons listed above, a non-economic evaluation was not performed for the liquids stream expansion alternatives. A non-economic evaluation of the solids stream alternatives, which involves a review of various biosolids stabilization technologies, is provided in Chapter 6.

5.9 Summary of Liquids Stream Recommendations

Based on the liquids stream treatment system capacity and condition evaluation provided in this chapter, HDR recommends the following liquids stream system improvements for inclusion in the next expansion project:

- Construct a third IFAS Basin with an anaerobic zone, a pre-anoxic zone, two Hybas zones, a swing zone, a post-anoxic zone, and a re-aeration zone. Also construct post-anoxic and re-aeration zones on the existing two IFAS trains, such that all trains are identical.

  - Confirm exact sizes of each basin during pre-design, based on constructability and available footprint.
  - Perform structural modelling to ensure that a minimum of 20 ft from the end of the IFAS basins and the edge of the secondary clarifiers is sufficient distance to prevent any structural damage during excavation and construction.
- Construct a second grit system with the third IFAS train, in the second layout alternative discussed in Section 5.6.4. Construct a grit chamber next to the third IFAS train, and provide accommodations for tying in the fourth IFAS train.
  - Add a second grit pump to route grit to the existing grit dewaterer and classifier.
- Install a fourth influent pump that is identical to the NWRF's existing three influent pumps. Add an isolation valve on the main header, and install a tee, flowmeter, and valve on new piping. Use two pumps for IFAS trains 1 and 2, and two pumps for IFAS trains 3 and 4.
- Repurpose the NWRF's existing RAS/IR centrifugal pumps for RAS/WAS pumping only. Install new propeller-style in-basin pumps for IR pumping in all three IFAS trains.
- Include the addition of a new disc filter and new headworks screen as bid alternates in the next expansion project.

Contents

6 Solids Stream Process Performance Evaluation and Alternatives Analysis ... 6-1

6.1 Introduction ... 6-1

6.2 Objectives and Purpose ... 6-1

6.2.1 Existing Solids System Evaluation: ... 6-1
6.2.2 Long-Term Biosolids Stabilization Study: ... 6-1

6.3 Existing Solids System Evaluation ... 6-2

6.3.1 Existing System Description ... 6-2
6.3.2 Summary of Design Year Solids Flows ... 6-7
6.3.3 Solids System Capacity and Condition Analyses ... 6-9
6.3.4 Existing Lime System ... 6-9
6.3.5 Existing Solids Pumping ... 6-11
6.3.6 Existing Solids Storage ... 6-14
6.3.7 Existing WAS Thickening ... 6-16
6.3.8 Existing Dewatering/Stabilization System ... 6-17
6.3.9 Existing Conveyance and Loadout ... 6-19
6.3.10 Summary of Existing Solids System Evaluation ... 6-20

6.4 Long-Term Biosolids Stabilization Study ... 6-23

6.4.1 Class A versus Class B Biosolids Discussion ... 6-24
6.4.2 Solids Stabilization Process Alternatives Evaluation ... 6-30
6.4.3 Solids Thickening Alternatives Evaluation ... 6-47
6.4.4 Solids Dewatering Process Alternatives Evaluation ... 6-56
6.4.5 Polymer System Optimization ... 6-59

6.5 Mineralogical Controls and Recovery ... 6-62

6.5.1 Deposition of Minerals ... 6-62
6.5.2 Struvite Recovery ... 6-64

6.6 Cost Evaluation of Narrowed Alternatives ... 6-65

6.7 Non-Economic Evaluation of Narrowed Alternatives ... 6-66

6.8 Summary of Solids Stream Recommendations ... 6-69

Tables

Table 6-1. Summary of Recommended 10 and 20 Year Design Values ... 6-7
Table 6-2: Town of Ere NWRF Existing Solids Treatment System Capacity Analysis ... 6-21
Table 6-3. Summary of Expansions/Improvements Needed at Erie NWRF ... 6-23
Table 6-4. Preliminary Solids Stabilization Technology Comparison ... 6-46
Table 6-5. Preliminary Thickening Technology Comparison ... 6-55
Table 6-6. Preliminary Dewatering Technology Comparison ... 6-58
Table 6-7. Total Anticipated Project Costs of Solids Stabilization Alternatives ... 6-65
Table 6-8. NPV Analysis for Keep Existing and ATAD Alternatives ... 6-66

Figures

Figure 6-1: Erie NWRF Process Flow Diagram ... 6-5
Figure 6-2: NWRF Lime System ... 6-10
Figure 6-3: NWRF RAS Pumping ... 6-12
Figure 6-4: NWRF Solids Pumping ... 6-13

Figure 6-5: NWRF Solids Dewatering Pumping....6-14
Figure 6-6: NWRF WAS Holding Tank....6-15
Figure 6-7: NWRF WAS Thickening System....6-17
Figure 6-8: NWRF FKC Dewatering Screw Press....6-18
Figure 6-9: NWRF Pressate Return Piping Mineral Build-up....6-19
Figure 6-10: NWRF Conveyance and Loadout System....6-20
Figure 6-11: Biosolids Use from Major POTWs – 2016....6-28
Figure 6-12: Aerobic Digestion....6-30
Figure 6-13: Anaerobic Digestion....6-31
Figure 6-14: Solar Greenhouse Biosolids Drying....6-32
Figure 6-15: BCR CleanB System....6-34
Figure 6-16: BCR Neutralizer System....6-35
Figure 6-17: Increased Concrete Corrosion at Neutralizer Installation....6-36
Figure 6-18: Sample ATAD System Layout....6-38
Figure 6-19: ATAD Class A Sludge....6-39
Figure 6-20: Alkaline Stabilization with Retrofit Option....6-42
Figure 6-21: RDP Lime Stabilization Schematic....6-44
Figure 6-22: Schwing Bioset Lime Stabilization....6-45
Figure 6-23: WAS Thickener Relocation to Thickening Room....6-49
Figure 6-24. Sample Gravity Belt Thickener....6-50
Figure 6-25. Huber Twin Disc Thickener....6-51
Figure 6-26. Parkson Hycor Rotary Drum Thickener....6-52
Figure 6-27. Huber Screw Press Thickener....6-53
Figure 6-28. PWTech Volute Thickener....6-54
Figure 6-29. Centrisys Centrifuge Thickener....6-55
Figure 6-30: Sample Dewatering Centrifuge....6-57
Figure 6-31: Sample Ashbrook Belt Press....6-58
Figure 6-32: Schematic of Cross Linking Differences between Polymers....6-60
Figure 6-33: Floc Quality Differences between Polymers....6-60
Figure 6-34: Polymer Aging Time for Various Mixing States....6-61
Figure 6-35: Example Aging Tanks for a Dewatering Polymer System....6-62
Figure 6-36: Struvite Solubility at Variable pH....6-63
Figure 6-37: AirPrex Process Schematic with Struvite Recovery....6-64
Figure 6-38: Photos from the AirPrex Facility and Product....6-65
Figure 6-39: Non-Economic Evaluation of Narrowed Alternatives....6-68

6 Solids Stream Process Performance Evaluation and Alternatives Analysis

6.1 Introduction

The Town of Erie's North Water Reclamation Facility (NWRF) is designed to treat 1.95 MGD of wastewater. Due to historical and anticipated rapid population growth in the area, the Town is planning an expansion of the NWRF to ensure the plant is adequately sized to handle the increased flows and loads. Projected flows and loads to the NWRF are discussed in Chapter 3, and the required expansions and improvements for the liquid stream treatment process are discussed in Chapter 5.

This chapter evaluates the existing solids treatment processes at the NWRF to determine the solids treatment process capacity and efficiency. Additionally, new solids treatment alternatives for increased flows and loads are evaluated to determine the best option for the Town. Various aspects of a functioning solids treatment system, including the performance, chemical usage, energy requirements, operation and maintenance needs, as well as the truck loading and hauling system are compared for all alternatives, and methods for optimizing each are discussed. This chapter presents and assesses these alternatives and provides recommendations based on those findings.

6.2 Objectives and Purpose

This chapter will include two primary components: an Existing Process Evaluation and a Long-Term Solids Stabilization Study.

6.2.1 Existing Solids System Evaluation:

- The goal of this task is to clearly identify the facility's existing stabilization process, its performance, and its capacity to successfully treat biosolids into the future. Evaluation of the existing solids handling process will include WAS tank, Lime tank, Feed tanks, tank mixing, lime system, solids pumping, WAS thickening, dewatering, stabilization/pasteurization process, polymer system, centrate system, and solids loadout.
- Review and analyze the existing system's ability to treat future flows and loads. Review and recommend improvements for process redundancy and contingency plans. Recommend minor equipment/control revisions that will allow the plant to continue operation during planning and design. The evaluation includes a table of current flow and loading conditions versus the rated capacity of the unit process as required for future CDPHE Regulation 22 submittals. The analysis will identify capacity restrictions in the unit processes and will predict when they will occur.

6.2.2 Long-Term Biosolids Stabilization Study:

- The first goal of this task is to provide a screening level of all applicable stabilization technologies. A screening level of technologies will allow the Town to understand industry trends and identify processes that may be worth evaluating in more detail. In a workshop setting, the potential stabilization systems will be presented and those worth evaluating in more detail will be identified.

- Define Class A and Class B biosolids and the defining characteristics for each, and analyze the benefits and disadvantages for achieving Class A and Class B end-products. Discuss regulatory drivers for both, as well as industry trends that may affect future regulations for Class A and Class B biosolids.
- Provide a comparative review and detailed analysis of narrowed solids technologies. Comparison criteria will include; capital cost, operational cost, maintenance cost, difficulty to implement into existing facility, impact on secondary treatment, odor production, regulatory risk, operator safety, operational risks, energy usage, chemical usage, non-economic factors, and others identified during development of the project. It is anticipated three (3) narrowed technologies will be detailed including:
    - Autothermal Thermophilic Aerobic Digestion (ATAD)
    - Alkaline Stabilization (Lime) Using Dewatered Cake
    - Chemical Stabilization Using BCR's CleanB® or Neutralizer Process
- Provide a recommendation for whether the Town should continue with the existing lime system to achieve either a stabilization goal of Class A or Class B biosolids, or if they should implement a new biosolids stabilization and dewatering system.
- Evaluate the Town's dewatering process and dewatering return flow's effect on the liquid treatment process. Return flow management, storage, or potential new technologies will be addressed.

Conclusions and recommendations from the Biosolids Stabilization Study will be included in this chapter.

6.3 Existing Solids System Evaluation

As mentioned above, the purpose of the existing solids system evaluation is to analyze Erie's existing solids treatment process and assess each piece of relevant equipment for condition, performance, and capacity. To do this, the maximum capacity of each unit was compared to the 2028 firm and total capacity requirements, as well as the 2038 total capacity requirements. Their condition and performance were also noted, particularly if NWRF staff have informed HDR of any equipment deficiencies. Solids processing equipment was then categorized based on those results into tiers of priority, in order to rank expansion and improvement measures, and provide a rough schedule of necessary project tasks. The results of this analysis and subsequent recommendations are provided in the following sections.

6.3.1 Existing System Description

The NWRF's existing solids treatment process utilizes an alkaline biosolids stabilization process, provided by FKC, to achieve Class A cake. Overall, the FKC Class A solids treatment system was designed to treat 6,120 dry pounds of biosolids per day.

The solids treatment process begins after the secondary clarifiers. Waste Activated Sludge (WAS) is pumped from the secondary clarifiers to a WAS holding tank with a capacity of 178,000 gallons. At current maximum month WAS flows, this tank provides approximately 3 days of WAS storage. WAS is then pumped to a lime tank with a capacity of 98,675 gallons. Here, lime is mixed with WAS until the slurry reaches a pH of higher than 12, to achieve Class A biosolids conditions required in 40 CFR, Part 503, *Standards for the Use or Disposal of Sewage Sludge* (the “Biosolids Rule”). The FKC operations and maintenance manual for the Class A solids treatment system states that the typical necessary lime usage to meet this requirement is 200 – 400 lbs lime per dry ton of biosolids. The NWRF currently uses about 1,200 lbs lime per day, which equates to about 380 – 420 lbs lime per dry tons of biosolids.

The WAS and lime slurry is pumped in parallel to the feed tanks, where the WAS and lime continue mixing. There are two feed tanks, and each has a capacity of 98,675 gallons, providing approximately three and a half days of storage. The lime and biosolids must remain above a pH of 11.5 for 22 hours in these tanks to achieve a Class A biosolids classification. The slurry is then transferred from the feed tanks to an FKC rotary screen thickener (RST), where polymer is injected to promote flocculation, and the slurry is thickened from an average solids concentration of 1.5% TS to an average of 10.4% TS. From the RST, the thickened solids drop into the FKC screw press, where steam is introduced to increase the biosolids temperature to a set-point of 72 degrees Celsius, and the biosolids are simultaneously pasteurized for 30 minutes retention time and dewatered, in order to meet the Class A requirements provided in the Biosolids Rule. A more in-depth description of the requirements for Class A and Class B biosolids is provided in Section 4.4.1.

The screw press dewaters the sludge from an average influent solids concentration of 10.4% TS to an average of 30.2% TS. The thickenate from the drum thickener and the pressate from the screw press are returned to the head of the plant. The thickening and dewatering system is fed continuously, 24 hrs a day, 7 days a week at an average flow rate of 30 – 40 gpm. A process flow diagram for the Erie NWRF is provided in Figure 6-1, and the solids treatment process is outlined in a red box.

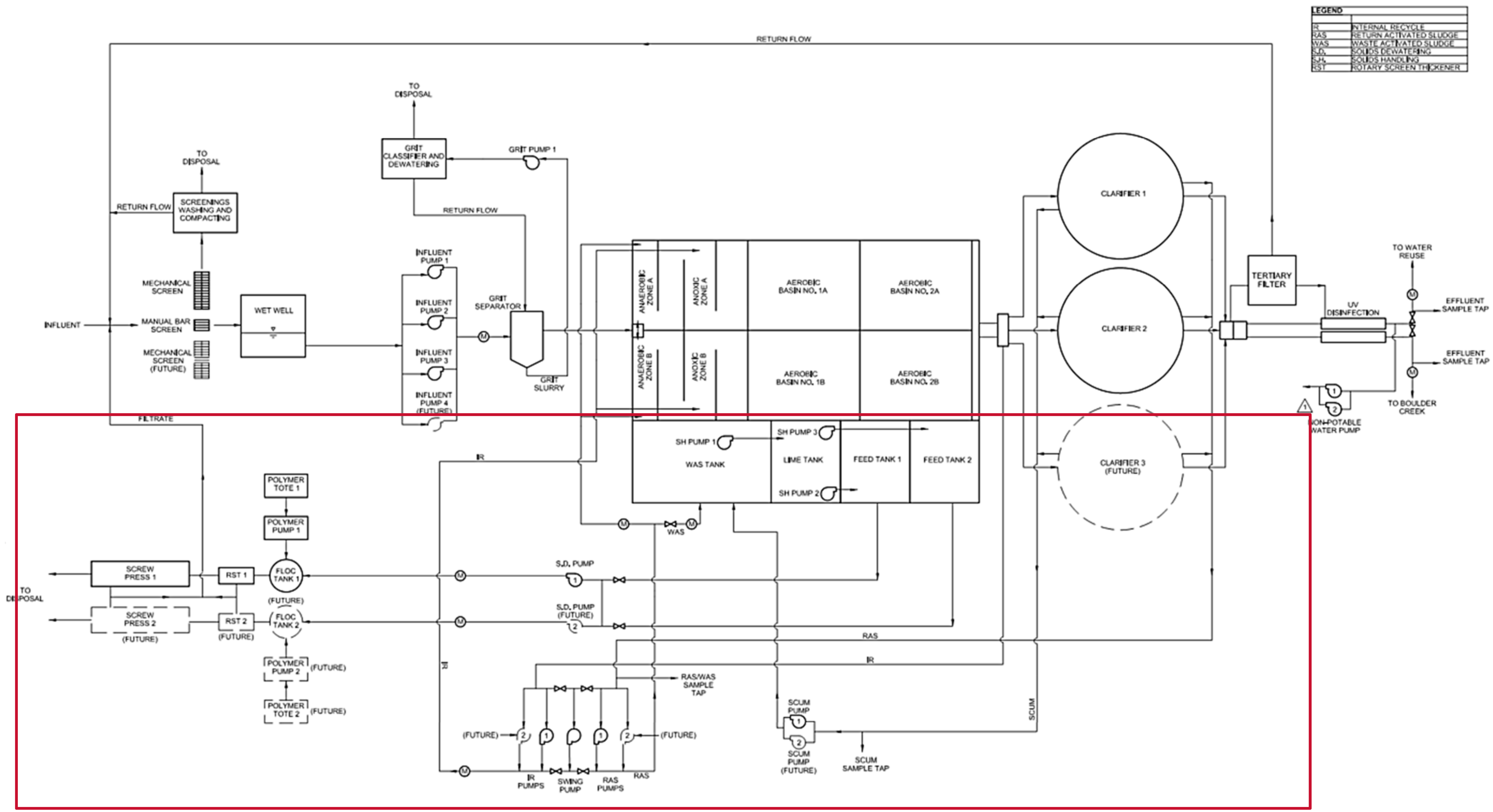


Figure 6-1: Erie NWRF Process Flow Diagram

This page intentionally left blank.

In 2014, the NWRF started experiencing frequent shutdowns of the dewatering system due to significant scaling in the screw press, caused by the high dosage of lime. To reduce the scaling effects of the lime, the Town experimented with dosing sulfuric acid to the feed tanks to decrease the pH to below 9.5 prior to dewatering. By decreasing the pH prior to polymer injection, the polymer requirements were decreased by approximately 35% when compared to the polymer usage with sludge at a pH of 12. As a result of this testing, the Town saw a reduction in the lime scaling on the dewatering screw press due to the lower pH sludge. Acid addition was consequently introduced as a permanent solution, and since then the scaling issues in the FKC screw press have decreased substantially.

In order to meet Class A biosolids requirements, biosolids must pass the testing requirements of one of two testing methods:

- Test Salmonella bacteria to a less than 3 most probable number (MPN) value per 4 grams of dried biosolids, or
- Test Fecal Coliform bacteria to a less than 1,000 MPN value per 1 gram of dried biosolids

Untreated biosolids sludge typically contains 100,000,000 MPN value of fecal coliform per gram of dried solids, meaning a facility must achieve greater than a 5-log reduction of fecal coliform to attain certified Class A biosolids. The Town of Erie uses the fecal coliform testing method to test their biosolids for Class A requirements. Recently, for unknown reasons, the biosolids produced from the FKC Class A system do not meet Class A requirements, regardless of how high a dose of lime is put into the system. The Town's biosolids do meet Class B requirements, however, because fecal coliform testing does confirm a fecal coliform count of less than 2,000,000 MPN per gram of biosolids. Because of these issues, the Town is interested in evaluating a new solids processing system that will both meet the requirements of the desired end-product classification, as well as reduce their total annual operating and maintenance costs.

6.3.2 Summary of Design Year Solids Flows

Chapter 3 provided a description of the methods used to obtain the projected flows and loads to the Erie NWRF. In order to accommodate for the necessary secondary treatment expansion that will affect the solids flows throughout the plant, the manufacturer of the NWRF's IFAS treatment system provided waste activated sludge flows from the expanded secondary treatment system, based on modelling. A summary of the influent flow and solids flow values for the ten and twenty year design frames are provided below in Table 6-1.

Table 6-1. Summary of Recommended 10 and 20 Year Design Values

Flow Parameters	2028	2038
Projected Population	49,226	80,184

Table 6-1. Summary of Recommended 10 and 20 Year Design Values

Flow Parameters	2028	2038
Avg. Day Influent Flow (MGD)	2.80	4.56
Max. Month Influent Flow (MGD)[a]	3.03	4.93
Max Month RAS Flow (MGD)[b]	3.03	4.93
Max Month RAS Flow (lb/day)[b]	346,200	563,290
Max Month WAS Flow (gpd)[b,c]	102,710	160,650
Max Month WAS Flow (lb/day)[b]	11,700	18,300
Max Month WAS/Lime Slurry Flow (gpd)[d,e]	112,230	175,540
Max Month Dewatered Solids Flow (lb/day)[d]	14,040	21,960

[a] Based on 61.5 gpcd wastewater generation rate per capita.
[b] Based on projected solids flow rates provided by Kruger. Assumes secondary treatment expansion.
[c] Assumes total solids concentration of approximately 1.37% TS of WAS/RAS, based on historical data.
[d] Assumes no change in existing solids treatment process. Based on a 1:5 ratio of lime to WAS solids use.
[e] Assumes total solids concentration of 1.5% TS of WAS/lime slurry leaving the feed tanks, based on historical data.

Note that the dewatered solids flow is based on a few assumptions:

- No changes are made to the plant's solids stabilization process in the next twenty years. Other stabilization alternatives, discussed further later in this chapter, have the capability to provide volatile solids destruction rates of approximately 50%. Volatile solids destruction would reduce the total solids volume sent to the dewatering system, thus reducing the daily dewatered cake volume that is hauled offsite.
- Since no changes are made to the solids stabilization technique in the next twenty years, it is also assumed that lime is added to WAS at the same ratio that it is currently added: approximately one ton of lime is added per five tons of treated biosolids. At 2038 design conditions, this equates to approximately 1.83 tons of lime used per day, which is nearly three times the amount currently used at the NWRF.

These values are used for the following solids system capacity analysis. In the following sections, each piece of equipment within the solids treatment process and its corresponding design capacity is compared against the values provided above, in order to determine if the plant's existing solids treatment system is adequately sized for the anticipated ten and twenty year flows and loads to the Erie NWRF, and to determine which equipment may need expansion or replacement within those timeframes.

6.3.3 Solids System Capacity and Condition Analyses

The solids system capacity analysis goals and methodology are the same as those for the liquids system capacity and condition analysis, provided in Chapter 5. The goal of the existing solids stream capacity analysis is to generate a high-level solids process equipment condition assessment, as well as a broad timeline of solids treatment equipment replacement and/or expansion. To this end, the existing solids treatment equipment capacities were evaluated for both firm and total capacity at 2028 and 2038 design years. Firm capacity is defined as the equipment capacity required to meet necessary flow demand and provide one standby unit for maintenance and downtime, and total capacity is defined as the capacity of all equipment without standby.

Once the equipment firm and total capacities were evaluated and compared to the 2028 firm capacity and 2038 total capacity requirements, each equipment piece in the solids treatment system was categorized into one of three priority tiers. These tiers were also described previously in Chapter 5 for the liquids stream treatment system evaluation.

- Primary Priority: Equipment improvements or additions that are required to meet 2028 firm capacity. To meet 2028 firm capacity, the equipment capacity must meet its necessary solids flow demand, which is a 2028 design flow value provided in Table 6-1, while also having a separate unit available for standby.
- Secondary Priority: Equipment improvements or additions that are not strictly mandatory for the next phase of expansions at the NWRF, but that will be required prior to 2028, in order to meet 2028 firm capacity needs.
- Tertiary Priority: Equipment improvements or additions which can further provide redundancy or capacity, ease maintenance, increase robustness, reduce equipment downtime, reduce permit violations, and reduce emergency overnight work.

This analysis resulted in a categorized list of improvements or expansions required at the Erie NWRF, and a rough timeline for these recommended improvements. A summary of the solids system capacity analysis, as well as the recommended timeline of improvements, is provided in Section 6.3.10.

6.3.4 Existing Lime System

The NWRF's lime system consists of a hydrated lime silo and feed system, manufactured by EnPro Technologies. See Figure 6-2 for a photo of the NWRF lime system. Major system components include:

- Lime silo (1533 cubic ft working capacity)
- Dust collector
- Bin activator
- Knife gate
- Volumetric feeder
- Mixer/Mix tank (750 gal)

- Space heater and exhaust fan

For plant robustness and ease of operations and maintenance, a chemical feed system should contain enough storage for 30 days. If the bulk density of the hydrated lime product used at the NWRF is approximately 35 lb per cubic ft, then the capacity of the lime silo is 53,655 lbs hydrated lime. For a current lime usage of 1,200 lb per day, the silo provides approximately 45 days of storage. For the anticipated 2028 and 2038 maximum month lime usages of 2,340 and 3,660 lbs per day, respectively, assuming no change to the solids stabilization or dewatering process, the lime silo provides approximately 23 days of storage in 2028 and 15 days of storage in 2038.

Figure 6-2: NWRF Lime System

Since the entire lime system and all of its components were provided as a package by the manufacturer, all of the related equipment listed above is sized to have a capacity that corresponds with the silo's capacity. Therefore, the lime system capacity as it currently exists does not meet 2028 firm capacity or 2038 total capacity requirements, since the silo would provide less than 30 days of storage in 2028 design year conditions.

The Erie NWRF staff have reported issues in the past with receiving bulk hydrated lime deliveries on time, resulting in the plant storing WAS longer in the WAS holding tank, and also attempting to run the FKC Class A system without lime; however, the solids did not dewater sufficiently in the screw press. Additionally, the lime system as it currently exists does not provide redundancy in the event of operational upsets, such as a delay in chemical delivery, or lime system equipment breakdowns. Therefore, if the NWRF continues to use the existing lime system to deliver lime for the FKC Class A System, additional capacity will need to be added to provide 30 days of chemical storage at 2028 conditions.

The requirement for additional lime system capacity can be delayed under the following conditions:

- The Town decides to implement a solids stabilization alternative at the NWRF that uses substantially less lime than is currently used. In this case the existing lime system's capacity should be re-evaluated for the lower lime usage rate.
- The Town decides to implement a solids stabilization alternative at the NWRF that does not use lime at all. In this case, the existing lime system may be repurposed, decommissioned, or left in place.
- The NWRF may continue to operate the solids treatment system as it currently is, and simply increase of the number of chemical deliveries per year. This will accommodate for the lower storage capacity of the silo. However, the ancillary equipment should be either confirmed to be capable of processing the required lime usage, or upsized to meet the required capacity.

6.3.5 Existing Solids Pumping

RAS/WAS and IR Pumps

The Town currently has four Gorman-Rupp self-priming centrifugal pumps that are used for internal recycle (IR), waste activated sludge (WAS), and return activated sludge (RAS) pumping. (See Figure 6-3.) Two are used exclusively for IR pumping, one is used exclusively for RAS/WAS pumping, and the last is a "swing" pump that can be used for either IR or RAS/WAS pumping. All four pumps are identical, although the first three were installed in 2012, and the second IR pump was added in 2017. Each pump has a 2.13 MGD design capacity at 20 ft head, 79% efficiency, and 7 ft net positive suction head required (NPSHr). The total resultant capacity of all four pumps is 8.52 MGD.

Figure 6-3: NWRF RAS Pumping

If the required RAS and IR rates, as suggested by Kruger, are 100% of influent flow for RAS, and 400% of influent flow for IR pumping, then the NWRF would need a total of five times the influent flow to meet both the RAS and IR required pumping capacity, and a small additional capacity for WAS pumping. This results in a 2028 firm capacity requirement of 15.25 MGD for all RAS/WAS/IR pumping. The existing IR/RAS pumps therefore do not meet 2028 firm or total capacity requirements. However, HDR discussed the possibility with the Town of converting all four RAS/IR pumps into just RAS/WAS pumps, and installing IR pumping in the IFAS basins with propeller style in-basin pumps. This allows the four existing centrifugal pumps to meet all 2028 and 2038 firm and total capacity requirements for RAS/WAS pumping, and also provides necessary IR pumping capacity in the IFAS basins. Therefore, the recommended improvement is to convert all four IR/RAS pumps to RAS/WAS pumps only, in order to meet 2028 RAS/WAS flow rate requirements, and also provide an extra unit for redundancy. The capacity needs for the internal return pumps to be added in the IFAS basins are discussed in Chapter 5, as part of the IFAS system improvements.

Solids Handling Pumps

Another set of solids system pumps include three solids handling pumps. (See Figure 6-4.) These three pumps feed solids from the WAS tank to the lime tank, and from the lime tank to each of the two feed tanks. They are also Gorman-Rupp self-priming centrifugal pumps, but are smaller than the RAS/IR pumps. Each pump has a capacity of 314 gpm at 23 ft of head, 52% efficiency, and 7 ft of net positive suction head required (NPSHr). The total capacity amounts to 942 gpm with all three pumps.

Figure 6-4: NWRF Solids Pumping

Filling both feed tanks with two solids handling pumps would take approximately 5.2 hours, and emptying the WAS holding tank with one pump would take approximately 9.45 hours. The exact 2028 firm capacity requirements of the solids handling pumps depend on the end-use of each of the solids storage tanks in 2028; however, regardless of their end-use, each of the solids handling pumps have nearly three times the capacity required to process the 2038 maximum month WAS flow into these tanks, meaning they will have sufficient capacity to process the necessary flows.

In the interests of maintaining plant robustness, the Town should consider the addition of a fourth solids handling pump, to provide redundancy for the pump that feeds solids from the WAS tank to the lime tank. If the existing pump goes offline, the plant must either hold solids for longer in the WAS tank while the pump is down, or rely on the 8-inch WAS overflow line that feeds into the lime tank. The pumps feeding each of the feed tanks have redundancy, since one of the two feed tanks may be used to convey solids, although reaching the 22 hour contact time between lime and WAS required for the FKC Class A biosolids system may be more difficult.

Solids Dewatering Pump

The last solids system pump evaluated for capacity and condition was the solids dewatering pump. (See Figure 6-5.) This pump is a progressive cavity Seepex pump, and it conveys solids from the feed tanks to the floc tank on the FKC rotary screen thickener. Its current maximum capacity is 60 gpm. Since the 2028 firm capacity requirements calls for approximately 78 gpm WAS/lime flows, plus one unit for standby, the solids dewatering pump does not meet 2028 firm capacity requirements. HDR recommends that the existing solids dewatering pump is upsized to handle at least 2028 flow demands, and that another pump is added to provide redundancy.

Figure 6-5: NWRF Solids Dewatering Pumping

6.3.6 Existing Solids Storage

As mentioned earlier, there are four existing solids storage tanks: the WAS holding tank, the lime tank, and two feed tanks. The WAS holding tank capacity is 178,061 gallons, and the remaining three tank capacities are each 98,675 gallons. These tanks are rectangular concrete tanks with FRP covers, and each share an east wall with the plant's existing IFAS basins. The WAS holding tank only has a KSB propeller-style mixer, and all four of the solids storage tanks contain Landia air jets for additional mixing.

The exact 2028 firm capacity requirements for the solids storage tanks are undetermined until their end-use is decided. If the Town decides to utilize a different solids treatment process than is currently used at the NWRF, these tanks may provide beneficial uses for a number of other solids stabilization alternatives. The solids stabilization alternative evaluations discussed later in Section 6.4 analyze the feasibility of re-purposing these tanks for various uses. However, for the purpose of evaluating the capacity and condition of these solids storage tanks for their current intended use in the alkaline biosolids stabilization process with lime, this analysis assumes that the tanks must be capable of the following at 2028 design conditions:

- The WAS tank must provide 24 hours of solids storage, in order to accommodate for any potential upsets to the solids treatment process.
- The lime tank must provide at least 2 hours of retention time, to allow for the required contact time between WAS and lime at a pH greater than 12.

- The feed tanks combined must provide at least 22 hours or retention time, to allow for the required contact time between WAS and lime at a pH greater than 11.5.

Based on these conditions, the solids storage tanks do meet 2028 firm capacity requirements. At 2028 maximum month solids flows, the WAS holding tank provides nearly 1.7 days of storage, the lime tank provides 23 hours of retention time, and the feed tanks provide about 46 hours of retention time.

Figure 6-6: NWRF WAS Holding Tank

However, in order to remain operational, all solids storage tanks should be examined visually to either confirm that the concrete is in appropriate condition for continued storage, or to identify repair needs. Figure 6-6 above shows the concrete deterioration in the WAS holding tank that has likely been caused by continued exposure to hydrogen sulfide gas. The concrete in the WAS tank has corroded severely enough such that the aggregate is visible on its surface; however, the structural integrity of the tank is likely adequate as long as the rebar is not visible. This tank must be taken offline, inspected and verified for structural soundness, blasted, and coated prior to continued use as biosolids storage. Additional inspections and repair needs for other concrete structures at the NWRF are discussed more in Chapter 7.

The NWRF staff have stated that the Landia jet mixers in the solids storage tanks do not perform as they're originally intended to. When air is pushed through the mixers, they cause foaming that causes inaccuracies in the level monitors. Additionally, plant staff have observed when the tanks were partially emptied that WAS and lime was settled at the bottom of the tanks, indicating that the mixers were not effectively mixing the contents of the entire tank. If the NWRF discontinues the use of lime in the solids treatment process, the mixing efficiency of the Landia jet mixers will increase due to a lower volume of denser lime particles in the tanks. However, improvements or replacements to these mixers should be considered to ensure that the solids storage tanks remain well-mixed, and that the thickening and dewatering processes receive homogenous and consistent sludge.

6.3.7 Existing WAS Thickening

The NWRF has an FKC rotary screen thickener that is used in conjunction with the FKC dewatering screw press to produce Class A biosolids. Figure 6-7 below shows the plant's RST unit elevated on a metal grating platform. The WAS/lime slurry is pumped from the two feed tanks to the flocculation tank, which has a capacity of 285 gallons, shown to the right of the RST in the figure below. After mixing with polymer, the biosolids are thickened in the RST and thickened solids are sent directly to the FKC screw press for dewatering and pasteurization.

The maximum capacity of the rotary screen thickener as part of the existing FKC Class A system is 60 gpm. However, input from FKC states that if the RST is operating independently of the FKC Class A system, it will most likely be able to process 80-100 gpm as is. If the screens in the RST are replaced with high open area screens, the capacity may be stretched to approximately 125 gpm. Since the 2028 firm capacity requirements call for approximately 78 gpm WAS/lime flow capacity plus an additional unit for standby, the existing RST may meet 2028 total capacity conditions, but since there is no redundant unit, the plant's thickening system does not meet 2028 firm capacity conditions.

Although the existing RST capacity meets 2028 total flow demands, it is important that a second thickening unit is added to ensure that redundancy needs are met. Once the new stabilization process is determined, various start-up tasks will be necessary to optimize the thickening process. For example, a polymer optimization process will likely be performed to determine which polymer product and what dosing level will interact with the sludge to produce a stable floc that will thicken to the desired total solids concentration. Additional improvements needed for the polymer system are discussed further in Chapter 7.

Figure 6-7: NWRF WAS Thickening System

6.3.8 Existing Dewatering/Stabilization System

After WAS/lime is thickened in the FKC RST, solids are sent directly to the FKC dewatering screw press, for simultaneous dewatering and pasteurization. The steam boiler provides high temperature conditions within the screw press that allows for pasteurization, and the solids retention time in the unit is about 30 minutes. Dried cake exiting the screw press has an average historical total solids concentration of nearly 30.2% TS. See Figure 6-8 for a photo of the dewatering screw press. Per input from the manufacturer, the capacity of the FKC Class A system at the Erie NWRF is 255 dry lbs per hour, which equates to 6,120 lbs per day. The 2028 firm capacity requirements for the dewatering process is 14,040 lbs per day solids flow, assuming that the lime to WAS biosolids ratio remains 1:5 until 2028, with one additional unit available for standby. Therefore, the FKC dewatering screw press does not meet 2028 firm or total capacity conditions. In fact, the FKC dewatering screw press capacity has been exceeded within the last few years (2016 and 2017) during maximum month flow conditions.

Figure 6-8: NWRF FKC Dewatering Screw Press

Assuming that the biosolids stabilization process remains the same, options to increase the dewatering screw press capacity to the required 2028 firm capacity are inherently difficult and cost-prohibitive. The FKC dewatering screw press units have a large footprint, due to their 30 minute retention time requirement, that render them difficult to retrofit in the existing Dewatering Building. Fitting one additional FKC screw press that is the same size and capacity as the existing screw press in the Dewatering Building is a challenging task. However, two additional screw press units would be required to achieve the 2028 total capacity requirements, meaning the Dewatering Building must be expanded to accommodate the necessary equipment.

As mentioned previously, NWRF staff has also had operation and maintenance issues in the past with the dewatering screw press, due to scale buildup in the unit from lime. Once the scaling was resolved with sulfuric acid, the O&M requirements for the system were significantly reduced. However, NWRF staff have noticed a build-up of lime scale in the piping to and from the dewatering screw press. Figure 6-9 below shows scale build-up in the dewatering pressate return piping from the screw press. Piping, valves, and fittings should be acid washed and maintained regularly to prevent as much lime scale build-up as possible.

Figure 6-9: NWRF Pressate Return Piping Mineral Build-up

Lastly, although the dewatering screw press is generally able to produce a dry enough cake, it continues to produce an end-product that does not meet Class A biosolids coliform fecal testing standards. If the Town decides to move forward with the existing FKC Class A system, additional testing and investigation should be performed with the FKC dewatering screw press to identify the cause of non-compliance.

6.3.9 Existing Conveyance and Loadout

After biosolids are dried in the FKC dewatering screw press, they are conveyed with an Austin-Mac Inc. shaftless screw conveyor to a storage area outside of the building. The solids are stored on a concrete surface on the ground underneath a lean-to structure. Cake is then transferred manually to a dumpster for storage, the dumpster is emptied into a hauling truck, and the biosolids are hauled offsite. See Figure 6-10 for the cake storage area. The capacity of the shaftless screw conveyor is 45 cubic ft per hour, which equates to roughly 20,200 lbs per day of solids. The shaftless screw conveyor does meet the 2028 total capacity requirement of 14,040 lbs per day, but does not meet the 2038 total capacity requirement of 21,960 lbs per day. However, until the final solids treatment system is decided, whether or not the NRWF will need a second redundant conveyor, or whether it will need to be relocated is yet to be determined.

Figure 6-10: NWRF Conveyance and Loadout System

HDR recommends that the following improvements be made to the NWRF's existing loadout system:

- Enclose lean-to structure to contain odors emitted from dewatered biosolids
- Install a distribution screw at the discharge end of the existing shaftless screw conveyor, so solids can be evenly distributed to a roll-off dumpster

6.3.10 Summary of Existing Solids System Evaluation

A summary of the existing solids system capacity analysis is shown below in Table 6-2. This analysis assumes no change to the existing solids stabilization process within the next twenty years. The last two columns of the table state whether or not the capacity of the plant's existing system is capable of meeting 2028 firm capacity conditions and 2038 total capacity conditions. The results of this analysis determined how all expansions or improvements needed at the Erie NWRF are categorized into each tier of priorities.

Table 6-2: Town of Ere NWRF Existing Solids Treatment System Capacity Analysis

Equipment Name	Existing Capacity Per Unit	Existing Total Capacity	Meets 2028 Firm Capacity Needs?	Meets 2038 Total Capacity Needs?
IR Pump	2.13 MGD, 20 ft head, 79% eff, 7 ft NPSHr	4.26 MGD	Yes[a]	Yes[a]
RAS Pump	2.13 MGD, 20 ft head, 79% eff, 7 ft NPSHr	2.13 MGD	Yes[a]	Yes[a]
Swing Pump	2.13 MGD, 20 ft head, 79% eff, 7 ft NPSHr	2.13 MGD	Yes[a]	Yes[a]
WAS Tank	178,061 gal	178,061 gal	Yes/TBD	Yes/TBD
Lime Tank	98,675 gal	98,675 gal	Yes/TBD	Yes/TBD
Feed Tank 1	98,675 gal	98,675 gal	Yes/TBD	Yes/TBD
Feed Tank 2	98,675 gal	98,675 gal	Yes/TBD	Yes/TBD
Lime Silo	1533 cu. Ft working capacity	1533 cu. Ft	No	No
Lime Mix Tank	750 gal	750 gal	No	No
SH Pumps	314 gpm, 23 ft head, 52% eff, 7 ft NPSHr	942 gpm	No[b]	No[b]
Solids Dewatering Pump	60 gpm max	10,800 lb/d	No[c]	No[c]
Rotary Screen Thickener	80 – 100 gpm max, 10-14 gpm shower	18,000 lb/d	Yes[c]	No[c]
Dewatering Screw Press	0.2 rpm screw rev, 255 dry lb/hr	6,120 lb/d	No[c]	No[c]
Dewatered Solids Screw Conveyor	45 cfh at 38 rpm	20,212 lb/d	Yes	No
Notes:	[a] Assumes IR/RAS/Swing pumps are all used for RAS pumping only. [b] One SH pump required to provide redundancy for pumping from WAS Tank to Lime Tank. [c] At 1.5% TS WAS/lime concentration for 100 gpm flow.			

This page intentionally left blank.

Table 6-3 below provides the recommended categorization of expansions and improvements needed at the Erie NWRF, based on the existing solids system capacity analysis. These recommendations and their respective categorizations are a culmination of the capacity analysis provided above, but they also incorporate input provided by the Town of Erie staff.

Table 6-3. Summary of Expansions/Improvements Needed at Erie NWRF

Primary Priority	Secondary Priority	Tertiary Priority
• Solids dewatering pump • WAS thickening unit • Dewatering FKC screw press (2 units)[a] • Enclose lean-to structure for solids storage • Distribution screw • Solids storage tank lining[b]	• Lime storage silo[a] • Lime mix tank[a] • Ancillary equipment for lime system[a]	• SH pump feeding solids from WAS tank to Lime tank • Landia jet mixers

[a] Denotes equipment expansions or improvements that may not be necessary if existing biosolids stabilization process is changed, and FKC Class A system is decommissioned.
[b] Exact blasting/coating/lining requirements for solids storage tanks to be determined based on complete condition assessment of tanks.

It is important to note that several of these expansion and improvement measures are not needed if the existing FKC Class A system is replaced with an alternative solids stabilization technique. Upon decision of the long-term biosolids stabilization process to be utilized at the Erie NWRF, those expansion and improvement measures should be altered to eliminate items related to the existing FKC Class A system that would be decommissioned.

6.4 Long-Term Biosolids Stabilization Study

As mentioned previously, the objective of the long-term biosolids stabilization study is to provide an alternatives analysis of several biosolids stabilization technologies. This analysis will address Class A and Class B stabilization technologies, as well as solids thickening technology alternatives, solids dewatering equipment alternatives, and cake handling options. The outcome of the long-term biosolids stabilization study is a selection of the most viable solids stabilization technology for the Erie NWRF, based on performance, cost, and a number of non-economic criteria, discussed in Section 6.7. Related components of the solids handling system, such as thickening, dewatering, centrate management, and cake handling, will also be considered and evaluated for feasibility.

6.4.1 Class A versus Class B Biosolids Discussion

In 1993 the US Environmental Protection Agency (EPA) established Title 40 Code of Federal Regulations (CFR), Part 503, *Standards for the Use or Disposal of Sewage Sludge* (the "Biosolids Rule"). This document provides regulation for the treatment, use, and disposal of biosolids for the protection of environment and public health. In an effort to make the regulations more understandable and accessible to the public, the EPA also published *A Plain English Guide to the EPA Part 503 Biosolids Rule*. This document contains six chapters that describe the requirements for disposal of biosolids in a more straightforward manner. States also may implement additional regulations on biosolids. Colorado Department of Public Health and Environment (CDPHE) published a Biosolids Regulation 64 that provides more stringent requirements, especially regarding land application.

The Biosolids Rule defines "biosolids" as "a primarily organic solid product produced by wastewater treatment processes that can be beneficially recycled."[1] It also established two classes of biosolids: Class A and Class B. There are two primary requirements for both biosolids classifications, including pathogen reduction and vector attraction. Each of these requirements have various options for meeting them. A brief summary of the applicable standards and regulations in the Biosolids Rule, and how they may affect the viability of various solids stabilization alternatives is provided in the following sections.

Class B Definition and Assessment

Class B biosolids are the end-product of sewage sludge that has undergone a Process to Significantly Reduce Pathogens (PSRP), as well as vector attraction reduction. Class B biosolids are permitted for land application but with the following restrictions:

- Land application of Class B biosolids on food crops: No harvest for 14-months to 38-months after applying
- Land application of Class B biosolids on animal grazing land: No grazing until 30-days after applying
- Land application of Class B biosolids on turf growing land: No harvesting for 1-year after applying
- Land application of Class B biosolids on public land: Restricted access for up to 1-year

In order to prove the necessary pathogen reduction, facilities are required to perform testing that confirms that fecal coliform bacteria are treated to less than 2,000,000 MPN per 1 gram of dried biosolids. Untreated biosolids typically contains 100,000,000 MPN per gram of dried solids, meaning fecal coliform bacteria must undergo at least a 2-log reduction.

There are a number of options for meeting Class B pathogen requirements. These include:

- Testing:

[1] Title 40 Code of Federal Regulations (CFR), Part 503, *Standards for the Use or Disposal of Sewage Sludge.* Environmental Protection Agency.

  - Results must show that the geometric mean of seven fecal coliform samples is less than 2,000,000 MPN per 1 gram
- Biosolids Treated in a PSRP
- Biosolids Treated in a Process Equivalent to a PSRP:
  - Facility must prove equivalency to a permitting authority
  - List of processes already approved by EPA: https://www.epa.gov/biosolids/examples-equivalent-processes-pfrp-and-psrp

The purpose of allowing processes equivalent to a PSRP is to accommodate for evolving technologies. However, there are five processes that, when following specific conditions and requirements, are established by the Biosolids Rule to be an approved PSRP:

- Aerobic Digestion: Solids are stored in aerobic conditions for 40-days at 20 deg C (68 deg F), or for 60-days at 15 deg C (59 deg F)
- Air Drying: Solids are stored on drying beds for 3-months, with two of those months having an ambient average daily temperature above 0 deg C
- Anaerobic Digestion: Solids are stored in anaerobic conditions for 15-days at 35 deg C to 55 deg C (95 deg F to 131 deg F)
- Composting: Solids are stored for 5-days with solids temperature above 40 deg C, (104 deg F) and for 4 of those hours the temperature in the compost pile is above 55 deg C (131 deg F)
- Lime Stabilization: Lime is added to raise the pH of the solids above 12.0 after 2-hours of contact

In addition to pathogen reduction, facilities must demonstrate vector attraction reduction in their biosolids in order to achieve Class B solids. Vectors are animals are drawn to unstabilized biosolids and that can transmit disease from one animal to another. These types of animals include flies, fleas, mice, and pigeons. There are twelve options for achieving appropriate vector attraction reduction. These include:

- Option 1: 38% Reduction in Volatile Solids
- Option 2: Additional Anaerobic Digestion on Bench Unit
- Option 3: Additional Aerobic Digestion on Bench Unit
- Option 4: Specific Oxygen Uptake Rate (SOUR) test
- Option 5: Aerobic Process at >40 deg F for 14-days
- Option 6: Alkali addition under specific conditions
- Option 7: Dried Biosolids, stabilized, >75% solids
- Option 8: Dried Biosolids, unstabilized, >90% solids
- Option 9: Inject below the soil
- Option 10: Incorporate into soil <6 hours after application
- Option 11: Cover biosolids with soil at end of each day (surface disposal only)
- Option 12: Alkaline treatment to pH >12 for 30 minutes (domestic septage only)

The Erie NWRF currently achieves a Class B biosolids with the lime stabilization alternative for PSRPs, and option twelve for vector attraction reduction, alkaline treatment. Fecal coliform testing proves the necessary 2-log bacteria reduction of the biosolids. However, to achieve Class A biosolids, the NWRF also must perform additional stabilization measures to further reduce pathogens.

Class A Definition and Assessment

Class A biosolids are defined as the end-product of a sewage sludge that has undergone a vector attraction reduction, as well as a Process to Further Reduce Pathogens (PFRP), such that pathogens are virtually unable to reactivate, regardless of storage time. Class A biosolids are permitted for land application without restriction, including for use on lawns, gardens, and food crops. To prove the necessary bacterial reduction for Class A biosolids, testing must confirm one of the two requirements below:

- Test Salmonella bacteria to less than 3 MPN per 4 grams of dried biosolids
- Test fecal coliform bacteria to less than 1,000 MPN per 1 gram of dried biosolids, thus proving greater than 5-log reduction

There are six available overarching alternatives for meeting Class A biosolids pathogen requirements. They are:

- Option 1: Thermally treated biosolids: Specific time-temperature requirements are provided in the Biosolids Rule for this alternative
- Option 2: Biosolids treated in high pH, high temperature process
- Option 3: Biosolids treated in other processes: Testing is required to prove necessary reduction of enteric virus and helminth ova
- Option 4: Biosolids treated in an unknown process: Testing is required for Salmonella, fecal coliform, enteric virus, and helmintha ova
- Option 5: Biosolids Treated in an Process to Further Reduce Pathogens (PFRP)
- Option 6: Biosolids Treated in a Process Equivalent to a PFRP
    - o Facility must prove equivalency to a permitting authority
    - o List of processes already approved by EPA: https://www.epa.gov/biosolids/examples-equivalent-processes-pfrp-and-psrp

The alternatives for meeting Class A biosolids standards also allow for other technologies that are equivalent to approved PFRPs, similar to Class B alternatives. The processes already established by the Biosolids Rule as approved PFRPs are:

- Composting: Solids are stored at a minimum of 55 deg C for three days in a static aerated pile, or for fifteen days in a windrow composting method
- Heat Drying: Biosolids are dried to at least 90% total solids, and the temperature of the biosolids exceeds 80 deg C
- Heat Treatment: Liquid biosolids are heated to 180 deg Cor higher for 30 minutes
- Thermophilic Aerobic Digestion: Liquid biosolids are aerated and heated to 55 – 50 deg C for 10 days
- Beta Ray Irradiation: Biosolids are irradiated with beta rays at dosages of at least 1.0 mearad at room temperature
- Gamma Ray Irradiation: Biosolids are irradiated with gamma rays from certain isotopes at room temperature

- Pasteurization: The temperature of the biosolids is maintained at 70 deg C or higher for at least 30 minutes

The vector attraction requirements and alternatives for meeting them are identical to those established for Class B biosolids. Therefore, the only additional requirement for Class A biosolids is further pathogen reduction.

The Town of Erie currently utilizes the alkaline treatment option to meet the necessary vector attraction reduction requirements. The PFRP used is pasteurization; the FKC dewatering screw press holds solids for at least 30 minutes at 70 deg C or higher. Fecal coliform testing is used to theoretically prove the necessary 5-log pathogen reduction. However, as noted previously, the NWRF is not consistently getting Class A biosolids. Therefore, an analysis is required to determine whether the Town should replace their existing FKC Class A system with a biosolids stabilization technology that will reliably produce Class A biosolids, replace it with a technology that is designed to produce Class B biosolids, or if they should keep the existing system in place, and either perform testing and improvements to consistently achieve Class A biosolids, or accept Class B biosolids from the system as is.

Challenges for Class A or Class B Biosolids Production

The most common end-use of biosolids is land application. (See Figure 6-11.) Biosolids provide a very beneficial form of reuse, and the market for land application with biosolids is promising. However, there are a few differences between Class A and Class B biosolids that give advantages and disadvantages for each end-product. For example, Class B material typically has a much greater odor component than Class A, due to the greater volume of live pathogens in the material. Odor potential and beneficial use of biosolids without offensive odors are important criteria that drive the biosolids stabilization alternative selection. Many areas are restricted in the type of biosolids that they use for land application not because of any criteria provided in the Biosolids Rule, but because of their proximity to residential establishments, which prevents them from applying biosolids that emit offensive odors. Nation-wide, there are hundreds if not thousands of odor complaints due to land application of biosolids. Therefore, a biosolids product that has as little odor emission potential as possible is more likely to be widely accepted by farmers and customers, since it reduces the risk of public complaints related to odor generation.

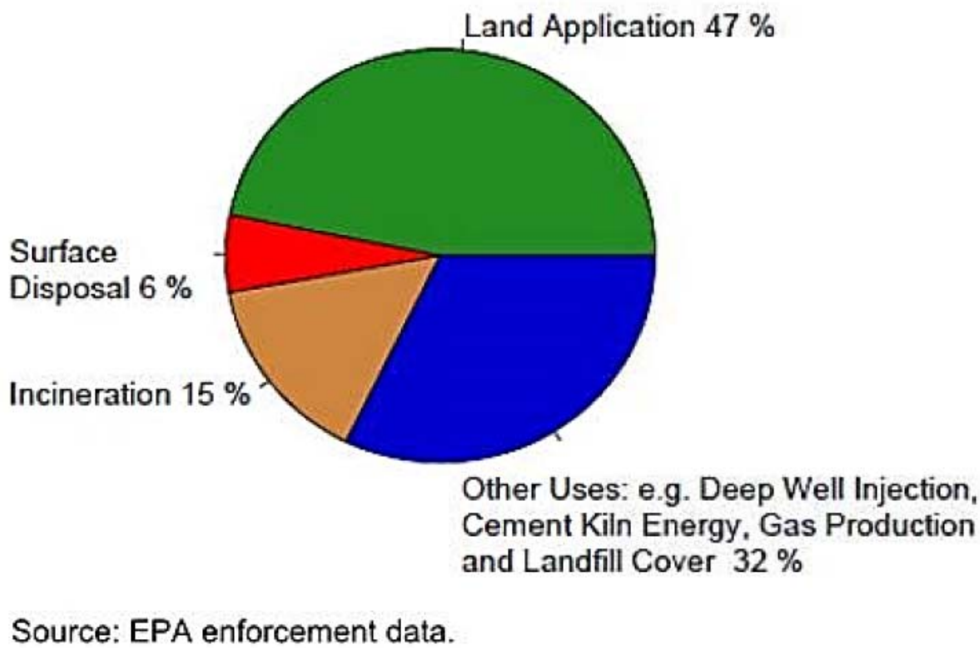


Figure 6-11: Biosolids Use from Major POTWs – 2016

In addition to the risk of odor generation at land application sites, public perception is another factor that may affect land application of Class A or Class B biosolids. A document published in November of 2018 by the EPA Office of Inspector General (OIG) has highlighted several potential challenges in the biosolids industry, due to the undetermined impacts of unregulated pollutants in municipal biosolids. This report summarizes the findings of an audit performed on the EPA's regulation and control of land application of biosolids. The OIG concluded that the EPA's controls over biosolids for land application were incomplete, and introduced a concern that human health and the environment may not be fully protected. They identified 352 pollutants, including pharmaceuticals, steroids, hormones, and flame retardants, present in biosolids that are currently unregulated due to a lack of data. Of those 352 pollutants, 61 were designated as acutely hazardous, hazardous, or priority pollutants in various programs. There were a number of deficiencies in the EPA's biosolids program identified in the report to support their findings:

- Reduced staff and resources in the biosolids program causes difficulties in effectively addressing weaknesses within the program.
- Insufficient data is present to fully understand the health and environmental impacts of biosolids for land application, particularly in regards to the 352 unregulated pollutants present in biosolids. Additional information needed includes human health and ecological toxicity values, exposure data, pollutant concentrations, environmental fate and transport properties, mobility mechanisms, and bioaccumulation data.
- EPA continues to monitor for 9 regulated contaminants in biosolids, but no new pollutants have been identified in 20 years.

- The EPAs website, biosolids labels, and public documents display a lack of transparency with regards to the uncertainties of the safety of biosolids for land application. Although EPA's website has modified its safety statement to point out the need for additional research, it does not explicitly state that biosolids cannot be proven safe for the public and environment until this research is completed.
- Additional information and data is required to provide comprehensive guidance for controlling and preventing potential risks to workers handling Class B biosolids.
- Pollutant distribution via biosolids runoff is not well tracked or regulated. There is concern that commonly used household chemicals that are transferred to WWTPs may end up in local surface waters via runoff, in agricultural soils, and in aquatic life.

Although this report highlights the deficiencies in the EPA's biosolids program, as well as the need for repairs and improvements, it is careful to emphasize that there is no data indicating that biosolids are actively harmful to human health or the environment; rather, the objective of this document is to point out that there is insufficient data and research available to rule out every possibility of potential harm to the public and environment via land application of biosolids. Therefore, the report provides recommendations for closing that data gap, and regulating land application of biosolids more thoroughly, including but not limited to:

- Issue guidance concerning what new technologies are allowable options or alternatives for biosolids pathogen reduction.
- Issue updated and consistent guidance on allowable and correct biosolids fecal coliform sampling practices.
- Modify EPA's website to include a statement that until the required research concerning unregulated pollutants found in biosolids is complete, the safety of biosolids cannot be guaranteed.

These recommendations have a few implications: first, updated pathogen reduction and fecal sampling practices are likely to change in the time period relevant to this master plan and its conclusion. Particularly, the report states that there are issues with Option 3 and Option 4, referenced earlier, for Class A pathogen reduction. Processes that are not already established as PFRPs may have to undergo stricter regulations and reevaluation by the EPA to pass Class A standards. Furthermore, if new rules are implemented for biosolids classification, costs of disposal for Class A or Class B biosolids may rise, meaning a process that reduces the total solids leaving the plant would provide an even greater cost benefit. Lastly, clarifying the EPA's website to state that the safety of biosolids cannot be guaranteed will likely cause some pushback towards land application of biosolids by residents. This could limit the Town's ability to land apply biosolids in the future; however, public outreach to educate residents on the benefits of land application of biosolids may help to ease public concerns.

6.4.2 Solids Stabilization Process Alternatives Evaluation

Due to the number of issues the NWRF has been having with their existing solids processing equipment, the Town is interested in a new biosolids stabilization system. The following sections will provide a screening level alternatives analysis for biosolids stabilization technologies. The technologies discussed include:

- Aerobic digestion
- Anaerobic digestion
- Solar Greenhouse Drying with Supplemental Heat
- BCR Chemical Biosolids Stabilization
- Autothermal Thermophilic Aerobic Digestion (ATAD)
- Intergovernmental Agreement
- Hauling of Biosolids to a Landfill
- Alkaline Biosolids Stabilization with Lime

The intended outcome of this screening level analysis is to establish a narrowed list of biosolids stabilization alternatives that undergo economic and non-economic comparison for further deliberation.

Aerobic Digestion

Aerobic digestion is one of the oldest technologies in wastewater treatment used to reduce biosolids volume and make them suitable for land application. When supplied with air, the microorganisms in thickened WAS rapidly consume organic matter and produce carbon dioxide gas. This technology has been proven to reliably produce Class B solids, and reduce solids volume for disposal by approximately 30 percent. Aerobic digestion is typically operated as a plug flow, continuously mixed reactor with coarse bubble diffusers.

Figure 6-12: Aerobic Digestion

Advantages to this process include:

- Well-proven technology
- Lower heating requirements than other alternatives
- Can run as batch reactor
- Easy to turn on/off (operation controlled by aeration)

Disadvantages to this process include:

- Capital Cost Intensive
- New tankage required
- New aeration, mixing, thickening, and tank covers
- High energy usage
- High operating cost

Per the requirements provided in the Biosolids Rule, the solids retention time (SRT) must be 60 days at 15 deg C. The 2038 maximum month solids loading is 18,300 lb per day, which equates to nearly 44,000 gallons per day at 5% TS. To meet the 60 day solids retention time, the NWRF must have 2.64 million gallons of storage available for aerobic digestion. This storage volume requirement could be satisfied by a single 130 ft by 130 ft by 20 ft deep tank, although it would be more prudent to construct multiple smaller tanks for maintenance. Due to the exceedingly high tank volume requirements for this alternative, aerobic digestion can be reasonably ruled out from the narrowed list of viable biosolids stabilization alternatives.

Anaerobic Digestion

Anaerobic digestion is another commonly used stabilization process in wastewater treatment used to reduce biosolids volume and make them suitable for land application. Microorganisms in thickened WAS are kept in anaerobic conditions, rapidly consume organic matter, and produce methane and carbon dioxide gas. This technology has been proven to reliably produce Class B solids, and reduce solids volume for disposal. The biogas produced from anaerobic digestion is commonly reused for a variety of energy needs, including power engines, mechanical power, heat and/or electricity, boilers, furnaces, or it can be sent to a natural gas pipeline for use elsewhere.

Figure 6-13: Anaerobic Digestion

Advantages to this process include:

- Well-proven technology
- Potential for biogas reuse
- Biosolids volume reduction

Disadvantages to this process include:

- Capital cost Intensive

- New tankage required
- New mixing, thickening, gas handling, and tank covers
- High energy usage due to heating requirements

In order to meet the 30 day retention time requirement, approximately 1.3 million gallons of tank volume is required, or approximately half the aerobic digestion requirement. However, due to the smaller size of the NWRF, it is highly unlikely that Erie will be able to feasibly reuse the small volume of biogas produced by an anaerobic digestion process, meaning that the biogas would have to be flared at all times. Additionally, the digesters must be heated to 95 deg F to 130 deg F at all times, which causes a very high heat demand with no potential to use biogas to offset that energy requirement. For these reasons, anaerobic digestion was eliminated from further consideration.

Solar Greenhouse Biosolids Drying with Supplemental Heat

Although biosolids drying with greenhouses is a well-established technology, biosolids drying with a solar greenhouse and supplemental heat is a newer technology that is entering the biosolids stabilization market. This technology involves sending dewatered cake to a greenhouse for storage and additional drying. Evaporation of liquid within the dewatered solids occurs by atmospheric interaction and also by the heated floor slab. The curved solar panels concentrate heat on the water tubing that runs along the center of the panels, which sends the water to an insulated tank for storage. This water is recirculated through concrete slabs to heat the biosolids, and a windrow machine is used to intermittently turn over solids. The manufacturer of this technology, Heat2Hydro, claims that the process can reliably produce Class A biosolids.

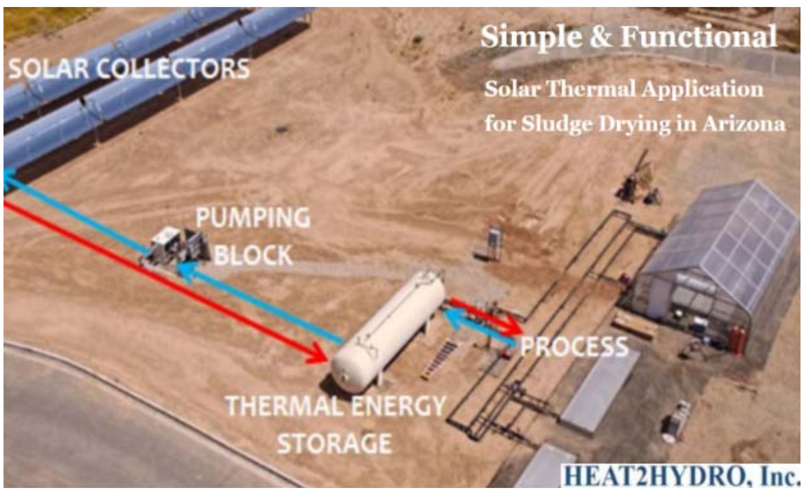


Figure 6-14: Solar Greenhouse Biosolids Drying

The benefits of this alternative include:

- Low/No energy usage
- Environmentally friendly

The challenges associated with this technology include:

- Large footprint (12,000 sq. ft. greenhouse)

- High capital costs
- Odor release/odor control issues
- Not a proven technology
- Not included by EPA in processes equivalent to a PFRP for Class A biosolids

HDR, Town of Erie staff, and Heat2Hydro met to discuss this technology and its viability for implementation at the NWRF. Although the technology does boast low energy usage and environmental sustainability, the general consensus was that there were various reasons for hesitation in pursuing this alternative further:

- There are zero full-scale facilities that are currently operational. HDR and Town staff were able to visit a pilot scale unit in Surprise, Arizona, but there is no performance data and credibility to be obtained from an existing full-scale system.
- Since the solar panels are not photovoltaic panels, but simply reflect and concentrate light on water tubes running through the center of the panel's curvature, the panels require direct sunlight to effectively heat the water. This means the technology does not work if it's even partially cloudy outside.
- If it's a cloudy day and the water for the heated slab cannot be heated with solar panels, there is no designed backup plan. The system would likely require a backup boiler than can send hot water to the thermally insulated tank. There would likely be portions of the year in which this system would rely heavily on the backup boiler, which significantly reduces the energy-savings benefit of this alternative.
- The technology has no established greenhouse design, which causes significant unknowns in its suitability for Colorado weather, costs, durability, and robustness.
- The manufacturer stated that the heated floor is typically constructed from concrete. This brings up concerns that the pad will undergo significant damage and spalling due to constant heating and freezing. Additionally, there is no prepared solution to address fouling on top of the pad, or fouling of the heated water tubes throughout the inside of the pad.
- There was no robust process guarantee and warranty to ensure that if the NWRF did have this system installed at the plant, that they would be insured in the event that the process did not effectively produce Class A biosolids.

For the reasons listed above, this alternative was eliminated from further consideration.

BCR Chemical Biosolids Stabilization

BCR provides two biosolids stabilization technologies: the CleanB system produces Class B biosolids, and the Neutralizer system produces Class A solids. Although the processes differ in their flow regime and level of treatment, the overall concept for both is the same: thickened WAS is mixed with an array of chemicals over a specific retention time, and their interaction provides pathogen and vector attraction reduction to generate stabilized biosolids.

CleanB is a continuous flow process that combines sodium chlorite and sulfuric acid to form chlorine dioxide (ClO_2), which is then injected into thickened WAS. The WAS and chemical mixture is processed through a serpentine tube design, which allows for the appropriate reaction time. (See Figure 6-15.) Solids are then discharged and sent to a dewatering system prior to disposal or land application. This process meets the necessary pathogen and vector attraction reduction to qualify for Class B biosolids. There are nine Clean B installations in the US, most of which are located in the southeast parts of the country.

Figure 6-15: BCR CleanB System

Major system components that are supplied by the vendor include:

- Contact Coil
- Chemical Delivery
- ClO_2 Generator
- Chemical Storage Tanks
- Valves and Inlet/Outlet Piping
- Air Compressor
- 40’ Conex Container

Additional items that would need to be added at the NWRF to complete the CleanB system include:

- Equipment Slab
- Metal Building
- WAS Pump
- Second Dewatering Screw Press
- Building HVAC System

The advantages of the CleanB system are that it meets Class B requirements and has previously been approved by the EPA as an equivalent process to a PSRPs, its cost competitive, features a compact modular design, and the full-scale unit is available for pilot testing at the NWRF.

The Neutralizer system is BCR's Class-AA EQ biosolids process that is PFRP approved by the EPA. It is similar to CleanB in that the first step combines sodium chlorite and sulfuric acid to make chlorine dioxide, which is added to thickened WAS. However, it differs from the CleanB system because it is a batch process rather than a continuous flow process, and it uses three additional chemicals to obtain Class A biosolids: sodium nitrate, ferric sulfate, and sodium hydroxide. See Figure 6-16 for a photo of the reactor tanks in the Neutralizer system. There are currently 9 installations in the US, and the tenth installation is currently under construction.

Figure 6-16: BCR Neutralizer System

System components for the Neutralizer system that are supplied by BCR include:

- Chemical Pumps
- Chemical Delivery
- ClO_2 Generator
- Reactor vessels
- Chemical Storage Tanks
- Valves and Inlet/Outlet Piping

Additional items that would need to be installed at the NWRF to complete the Neutralizer system include:

- Equipment Slabs
- Metal Building
- WAS Pump
- Second Dewatering Screw Press
- Building HVAC System

HDR and Town of Erie staff had the opportunity to visit two Neutralizer installations in Jacksonville Florida, and meet with BCR and plant staff to get a better understand of the process. In general, there were a few noticeable advantages for this technology:

- Little to no odors observed at the plant associated with the Neutralizer system, with no solids storage onsite
- Solids dewater sufficiently

However, several challenges exist with both the CleanB and Neutralizer systems, including:

- Preliminary results from pilot testing performed with a CleanB unit and observed by HDR show that the dewatered biosolids can reactivate and produce odors after being stored for approximately 3 days.
- Permitting requirements and the level of effort associated with obtaining requirement permits with CDPHE are unknown, since there are no Colorado installations.
- The system is a chemical process that would replace an existing chemical process. However, very little of the NWRFs existing chemical feed facility could be reused for CleanB or the Neutralizer process.
- Both of the systems involve toxic chemicals and require increased chemical handling by plant staff, which introduces a safety risk.
- Chemicals cause increased wear and corrosion on system components, including pumps, valves, and ancillary instrumentation.
- Chemicals cause increase wear and corrosion on surrounding concrete, reducing the useful life of the surrounding concrete structures.

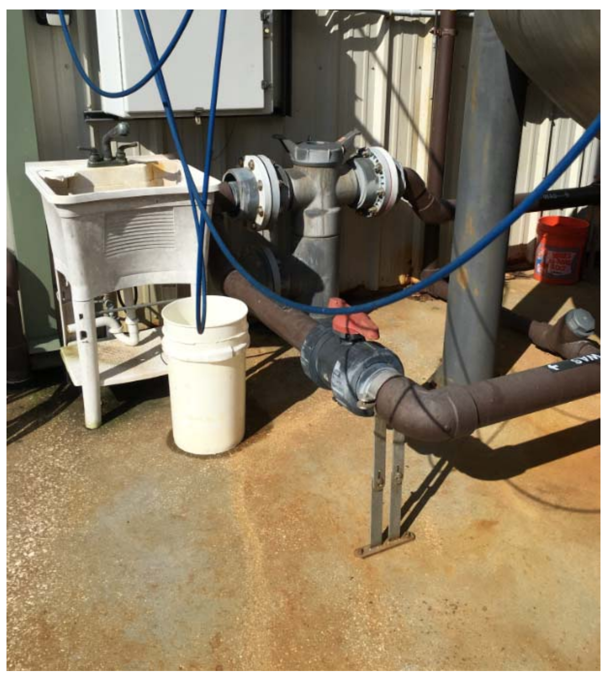


Figure 6-17: Increased Concrete Corrosion at Neutralizer Installation

- Additional dewatering capacity is required for both the CleanB and Neutralizer alternative, since no volume reduction is provided in the stabilization processes, and the NWRF's existing screw press is currently at maximum capacity.
- There are no existing cold weather installations. Chemical storage tanks and delivery lines must be in a climate-controlled environment to prevent

crystallization, so chemicals must be at or above 60 deg F at all times. Chemical delivery lines and bulk storage tanks must be heat-traced.

- Disruptions in chemical delivery result in the need to haul liquid biosolids for disposal.
- Operator input revealed that the Neutralizer system needed frequent attention while the reactors filled.

HDR and the Town of Erie eliminated BCR's CleanB technology from further consideration, due to the various challenges stated earlier, as well as its inability to produce Class A biosolids. Although the Neutralizer chemical stabilization system is accompanied with several caveats to consider, HDR carried this technology forward in the narrowed biosolids stabilization alternatives evaluation. The competitive cost and the option to keep producing Class A biosolids with the Neutralizer system provided incentive to investigate this option further.

Autothermal Thermophilic Aerobic Digestion (ATAD)

ATAD is a two-step aerobic digestion system patented by Thermal Process Systems (TPS) that utilizes high temperatures to trigger microbial activity with high carbon consumption thermophiles. This technology is a commonly implemented stabilization process for small to mid-size wastewater facilities. It reduces biosolids volume by nearly 50 percent, and reliably produces Class A biosolids.

The process begins by sending thickened WAS to the ThermAer reactors. In the ThermAer reactors solids are heated to 65 – 70 deg C, and mixed rapidly via jet aeration. The pH is approximately 8 - 8.5. Volatile solids reduction begins to occur, and total solids content drops to about 3 - 4% TS. Foam production is managed with hydraulic foam control cones. After an SRT of approximately 12 days, flow is sent to the storage nitrification-denitrification (SNDR) reactor. In this second step, the temperature is decreased to 35 – 40 deg C, and the solids are further volatized while undergoing nitrification and denitrification. The SNDR process also helps to minimize odors in the final biosolids product, provide additional time for further vector attraction reduction, and decrease ammonia and soluble chemical oxygen demand (COD). The control system utilizes pH, temperature, and ORP data. After an SRT of 9 days, solids are sent to the dewatering system.

System components supplied by the manufacturer include:

- ThermAer/SNDR jet motive pumps
- PD Blowers
- Foam control
- Instrumentation
- Heat Exchanger
- Transfer Pumps
- Control Panels
- MCC
- Biofilter (fan, scrubber, air plenum, and organic/inorganic media)

Additional items required to complete the system include:

- Tanks (for ThermAer, SNDR, and biofilter)
- Building
- WAS Pump

- Building HVAC System

HDR requested preliminary sizing and layout information from TPS to accommodate 2028 and 2038 flows and loads at the Erie NWRF. TPS provided the following tank sizes:

- 2028 Conditions:11,700 lbs/day – Requires two (2) ThermAer Reactors (12 day SRT) and one (1) SNDR Tank (9 day SRT)
    - o Each ThermAer tank is 50’ x 28’ x 24’ deep
    - o SNDR tank is 50’ x 40’ x 24’ deep
- 2038 Conditions:18,300 lbs/day – Requires three (3) ThermAer Reactors (12 day SRT) and two (2) SNDR Tanks (9 day SRT)
    - o Tank sizes remain the same as for 2028 conditions
- Biofilter: 40’ x 30’ x 10’ concrete tank with inorganic & organic media

A conceptual layout of the system is provided in Figure 6-18. As shown, the ATAD facility would contain two ThermAer fixed cover tanks and one SNDR fixed cover tank, as well as additional building space to accommodate an electrical room, and the necessary ancillary equipment, including blowers, pumps, heat exchangers, the MCC, and control panels. This layout shows the necessary footprint required for 2028 conditions. However, additional space would be provided for expansion to 2038 conditions in the future.

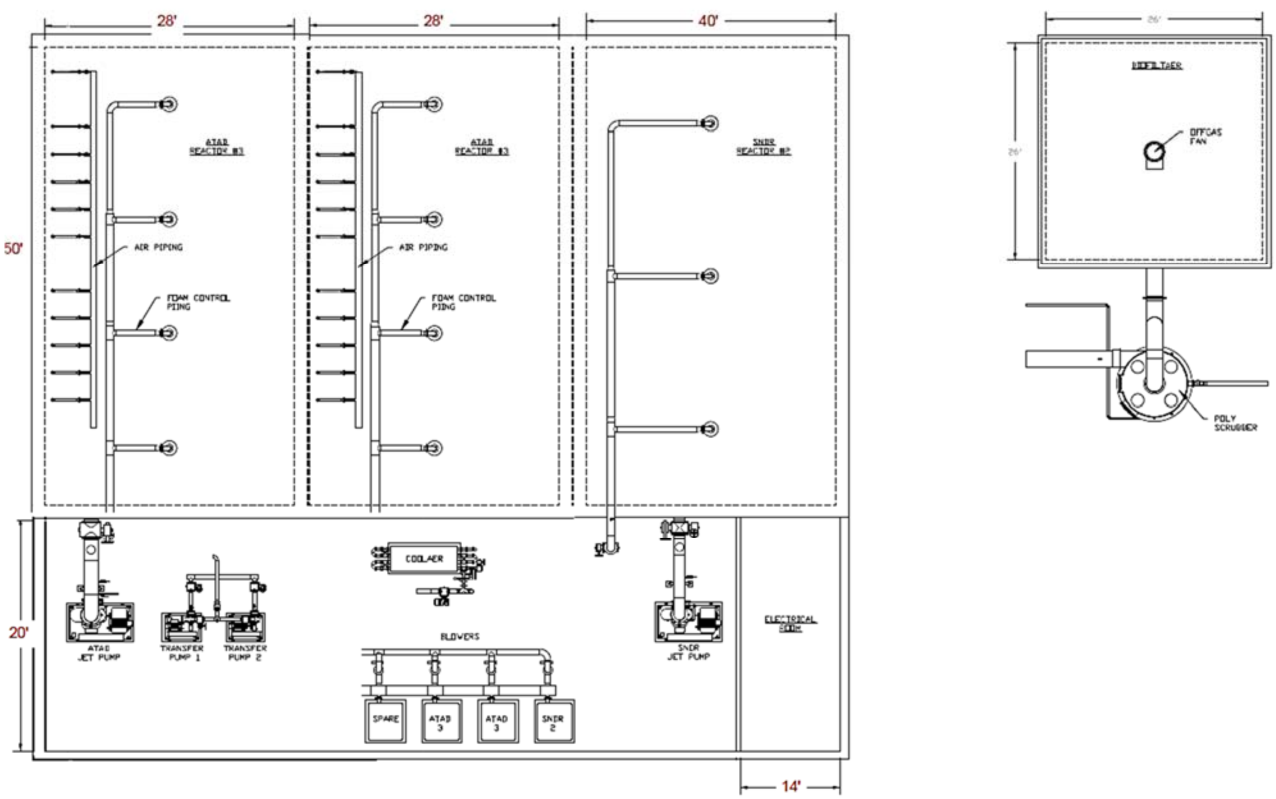


Figure 6-18: Sample ATAD System Layout

The benefits of this system include reliable production of a Class A product that has little odor potential. See Figure 6-19 for a photo of a typical ATAD sludge product. The technology is already established by the EPA as an approved PFRP, and ATAD biosolids have been shown to have high demand among farmers and customers. The biosolids volume production is also substantially reduced in this stabilization alternative. Volatile solids reduction eliminates nearly 50% or more of solids volume, and the Erie NWRF would also eliminate the need for lime, which would further reduce their biosolids volume they would be required to haul. The ATAD process requires no chemical use, but relies entirely on temperature and retention time to perform stabilization. This reduces the amount of chemical handling required by staff, removes the plant's reliance on chemical delivery and availability for solids processing, and makes the system a very sustainable and environmentally friendly technology, Lastly, the expansion capabilities of this system make it sustainable as a long-term solution for the Erie NWRF, since it can be easily amended to provide enough capacity for rapidly increasing solids flows.

Figure 6-19: ATAD Class A Sludge

However, this alternative does have some challenges: its primary shortcoming is cost. The capital costs associated with the system include new building space, tankage, aeration, mixing, thickening, tank covers, odor control, and foam control. Furthermore, energy costs associated with ATAD are higher than other alternatives, due to the high temperature and mixing requirements of the system. Lastly, although the system is meant to be automated, other facilities with ATAD have reported that operation of the system can be temperamental, and difficult to optimize. However, TPS has demonstrated reliable service in aiding customers with startup, training, and optimization processes.

The long-term sustainability and end-product quality of this alternative make it an attractive alternative for the Erie NWRF. Therefore, HDR carried this alternative forward for further deliberation.

Intergovernmental Agreement

This alternative does not involve a biosolids stabilization process that would be implemented at the Erie NWRF. Instead, this alternative considers the feasibility of pumping unstabilized biosolids to another nearby wastewater treatment plant for further treatment and dewatering. This type of arrangement is established with an intergovernmental agreement (IGA). Since the NWRF would be pumping either WAS or thickened WAS with a total solids content of 0.5 percent to 5 percent TS, it would be important to ensure that the solids are pumped downhill, and that plenty of access is provided for maintenance. The benefit of this arrangement is that it would effectively eliminate the solids treatment process at the Erie NWRF, and solve all future capacity restraints associated with solids handling equipment.

However, there are several difficulties associated with this alternative. The accepting WWTP must already have the hydraulic and treatment capacity to accept the Erie NWRF solids stream, and must be capable of withstanding periods of high flow demand. Additionally, due to the difficulties in constructing a sludge conveyance line that crosses Interstate 25, the plant would most likely have to be located on the western side of the interstate, which would rule out a number of larger WWTPs.

Given the rapid growth rate predicted in Erie, and the corresponding growth in solids flows at the NWRF expected over the next 10 to 20 years, it is unlikely that an IGA could be sustained for an extended period of time. The accepting WWTP would be subjected not only to the growth rate within their own municipality, but also to the rapid growth rate in Erie. Lastly, Erie would be expected to pay a cost per dry ton of solids sent to the accepting WWTP. Therefore, this alternative has a high initial capital costs associated with constructing the sludge pumping and pipeline, as well as high daily operating costs. Due to the high capital costs and low likelihood of establishing an IGA with a municipality that is already appropriately sized for future flows, well located, and willing to enter the agreement at a low operating cost for Erie, this alternative can be reasonably eliminated.

Hauling Biosolids to a Landfill

Another alternative that avoid the need for a new biosolids stabilization process at the NWRF is hauling biosolids to a landfill. This option circumvents the regulations that are required for land application of biosolids by disposing of solids in a co-disposal landfill, which is a landfill that combines biosolids with municipal solid waste. Co-disposal landfills typically require at least 18 percent total solids concentration of the biosolids, meaning that the Erie NWRF would still need to plan for solids dewatering prior to hauling. This alternative is different than using biosolids to amend final cover material at landfills. That practice is technically a form of land application, and thus is subject to regulations provided in the Biosolids Rule. However, although disposal of biosolids in co-disposal landfills is not regulated by EPA 40 CFR Part 503, it is still regulated under Part 258. These regulations provide standards for pollutant limits, management practices, operational standards for pathogens and vector attraction, and monitoring.

Landfilling is generally a useful alternative when land application of biosolids is not viable. Land acquisition restraints, a high concentration of metals or other toxins in the biosolids, or odorous biosolids are all conditions for which landfilling may be more viable than land application. However, there are several disadvantages associated with this option, including:

- The elimination of biosolids reuse potential, which is contrary to the EPA national beneficial reuse policy

- Extensive planning requirements to establish a proposed landfill site and operation of the site
- The risk of a landfill refusing to accept biosolids from the NWRF in the future, for a variety of reasons, including odor, pollutant concentration, total solids content, or volume
- Potential environmental impacts due to leachate flow into groundwater, causing contamination with nitrate, metals, organics, or pathogens
- Environmental impact due to traffic volume, land use, air quality, public health, and wildlife interference
- Tipping fee cost fluctuation

For the reasons listed above, this alternative was deemed too risky to pursue further. It is recommended that Erie consider alternatives that leave the possibility for the Town to dispose of their biosolids via land application open.

Alkaline Biosolids Stabilization with Lime: Existing System Modification

As already discussed, the Erie NWRF uses an alkaline biosolids stabilization process with hydrated lime. However, there are variations of this alternative that should be considered. In general, lime stabilization of solids involves adding a hydrated form of calcium oxide (lime) to the solids. The addition of lime increases the pH to an environment that is unfavorable for the growth of pathogens, thus, stabilizing the solids. Lime stabilization of solids can achieve Class A and Class B products. However, Class A lime stabilized solids are often sent to a landfill, due to the appearance, odor, and high pH of the solids, which make them undesirable for agriculture and land application uses.

There are two sub-alternatives for alkaline biosolids stabilization with lime: retrofitting the existing system to produce Class B biosolids, RDP lime stabilization to produce Class B biosolids, and a new alkaline/pasteurization process to produce Class A biosolids.

The first sub-alternative is modifying the NWRF’s existing lime stabilization system to send WAS only to the RST, dewater in the screw press without steam addition, and mix lime with dewatered sludge prior to storage. This process would produce Class B biosolids, since the pasteurization process is effectively eliminated. In order to execute these modifications, a tubular drag chain conveyor would be installed to transport lime from the lime storage silo to dewatered solids. This is approximately a 100 ft stretch across a concrete drive and a steep slope, meaning a couple vertical and horizontal turns in the conveyor would be required. The conveyor would drop lime into a new lime and biosolids mixing screw, which would then deposit lime and biosolids in a roll-off dumpster. See Figure 6-20 for a rough schematic of the system.

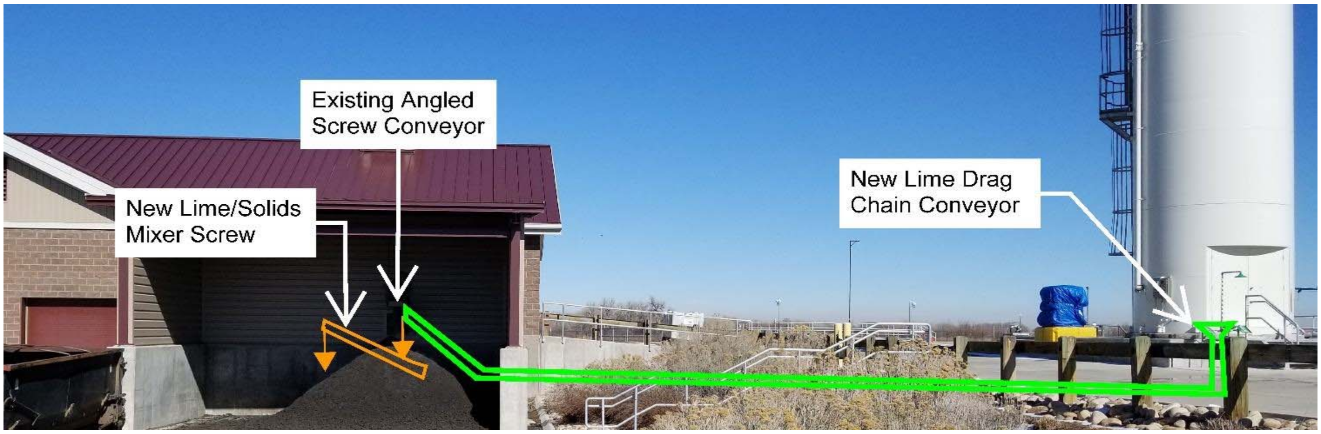


Figure 6-20: Alkaline Stabilization with Retrofit Option

There are several design considerations for this sub-alternative that would be required to ensure that the drag chain conveyor performed as desired. Hydrated lime is a very fine powder, similar to dry cement. Any moisture addition, clogging, or grinding may prevent the material from being conveyed properly, or cause motor overload and fault. Design considerations include:

- A cleaning mechanism is required with the conveyor to prevent lime from clogging the tube. Options include:
  - Brush box: Set of rotating brushes in open-ended box on the discharge of the conveyor cleans pucks that pass between them.
  - Chain vibrators: Set of weights mounted on a shaft connected to a spring plate/hammer just above the flights at tube conveyor discharge; vibration causes hammer to hit the plates, removing material buildup.
  - Scraper plates: Set of four metallic plates at 12, 9, 6, and 3 o’clock positions on pucks. This option is typically a retrofit added only if clogging issues are noted, since plates become a replacement item and also induce wear to the tube.
- The maximum number of turns in a drag chain conveyor is three 90 deg bends. Any additional turns may increase the wear potential on the tube, chains, pucks, and motor.
- To manage moisture intrusion potential the tube conveyor must be insulated and heat traced.
- Cold weather may cause product to freeze and clog the conveyor, particularly if the material gets wet. Product should not sit idle in the conveyor, particularly during cold weather conditions.
- Discharging lime to heated/moist environment causes clogging. Ventilation and dust collection is needed at the discharge point to prevent material build-up.

There are some advantages to retrofitting the NWRF’s existing lime system to produce Class B biosolids. Sending lime directly to the dewatered biosolids eliminates scaling in the screw press, solids storage tanks, and associated piping. Lime consumption would also be reduced, which also reduces the end-product haul off weight. Lastly, this alternative allows for the maximum amount of existing equipment reuse and repurposing.

However, several disadvantages exist with this sub-alternative:

- There are potential difficulties conveying lime in a drag chain conveyor, as discussed above.
- Continued lime use sustains the NWRF's reliance on chemical delivery and fluctuating costs.
- Additional equipment is still required to complete the system. Although lime consumption is reduced, another lime silo may still be required before 2028 to provide 30 days of chemical storage.
- No redundancy for the system unless a new lime silo, second tube conveyor, and second mixing screw are installed.
- There is a significant risk of frequent conveyor failure and long-term outages due to lime clogging the conveyor.
- This is a custom-made, one-off design.
- This is not a long term solution, but rather an attempt to reuse as much existing equipment as possible.
- The end-product would be a worse quality biosolids than the NWRF's current end-product
- This would introduce a new process for plant staff to learn and optimize.
- This option may increase polymer consumption to achieve the desired dewatered cake solids concentration, as well as a polymer product change.
- Lime dust may be generated at the discharge location.
- Expansion to meet increasing capacity demands requires the purchase of another system.

HDR discussed this alternative with Erie staff, who expressed concern that this system may still cause the need for them to send their biosolids to a landfill. Although it may be more cost-effective than other alternatives, and reuses existing equipment, it does not provide a solution to the plant's current biosolids quality, and may introduce a new set of operation and maintenance issues. Therefore, due to the various risks associated with the workability of this sub-alternative, as well as its improbability as a long-term solution, this option was eliminated from further consideration.

Alkaline Biosolids Stabilization with Lime: RDP Lime Stabilization

The RDP alkaline biosolids stabilization technology is a more conventional lime stabilization process that produces Class B biosolids. However, it is very similar to the retrofit alternative discussed above with regards to its process. Lime is stored in a silo and fed to a lime supply hopper, a lime feed screw conveyor, and then to a lime addition screw conveyor, which distributes the hydrated lime evenly across the sludge and lime mixer. On the biosolids portion, dewatered cake is sent to a sludge weighing conveyor, which then feeds the sludge and lime mixer as well. Dewatered solids and lime are combined in the mixer and conveyed to a discharge conveyor, which is fitted with an odor/steam/dust control hood. The discharge conveyor moves solids to a hauling truck or loading storage location. See Figure 6-21 for a schematic of this process.

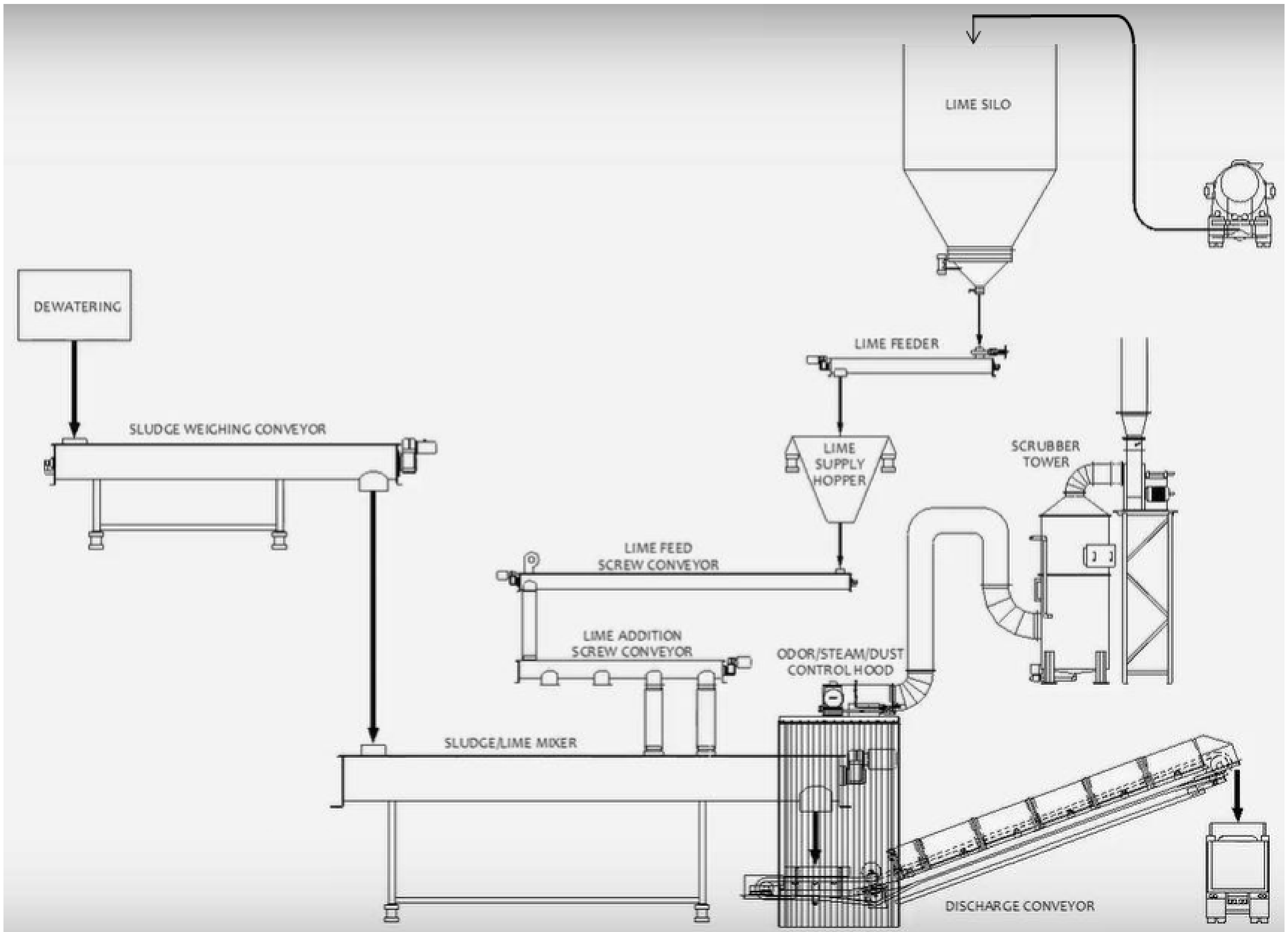


Figure 6-21: RDP Lime Stabilization Schematic

The advantages of this system are that it is from an established manufacturer and is furnished as a package. Appropriate lime conveyance is more likely, particularly since all conveyors are screw conveyors, which are better able to convey lime over short distances. Additionally, this system utilizes some components that exist already at the NWRF and may be reusable. For example, the discharge conveyor may possibly be repurposed and fit within this system. However, the lime silo may not be reusable, due to its distance from the plant's dewatering process.

This alternative ultimately does not provide enough benefits to outweigh its disadvantages and be a feasible option for the Erie NWRF. The capital costs are high for this system, since it is essentially a package that would replace the plant's existing lime system. Furthermore, the end-product would again be worse quality than the plant's existing biosolids product. This system does not eliminate the need for lime or reduce the plant's haul away biosolids volume, it introduces a new process to the plant, and it does not provide process redundancy unless two full systems are purchased. For these reasons, this alternative was eliminated from further consideration.

Alkaline Biosolids Stabilization with Lime: Schwing Bioset System

The last lime stabilization process alternative is the Schwing Bioset Alkaline Stabilization and Pasteurization process to produce Class A biosolids. This process has been approved by the EPA as an equivalent process to a PFRP. This system is the most unique of the alkaline stabilization processes, because it uses quicklime and sulfamic acid addition to biosolids to produce high temperature and high pH conditions that provide necessary pathogen and vector attraction reduction for Class A biosolids. First, quicklime and sulfamic acid are added to a chemical mixing hopper, and then to a mixing screw, where they are combined with biosolids. The reaction between the acid and lime produce heat, which provides the necessary temperature component. A piston pump transfers the material to an insulated reactor vessel, where it is stored for 40 minutes at 55 deg C. Due to the release of ammonia, which kills pathogens prior to temperature, EPA granted the lower temperature requirement for Class A biosolids. After the solids are stabilized in the reactor, they are conveyed to a storage hopper or hauling truck for disposal or land application. The process schematic is shown in Figure 6-22.

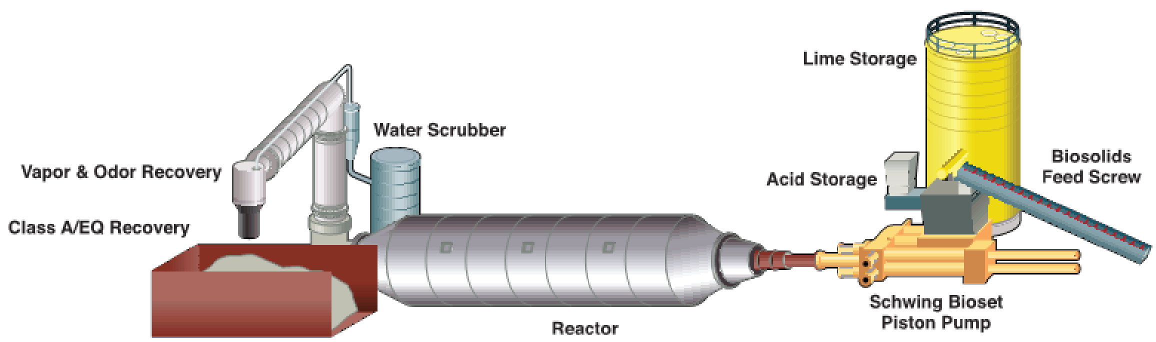


Figure 6-22: Schwing Bioset Lime Stabilization

System components for this process include:

- Biosolids Collection Screw Conveyor
- Lime Feeder
- Sulfamic Acid Feeder
- Twin Screw Mixer
- Reactor Feed Pump
- Hydraulic Power Unit
- Reactor Vessel
- Ammonia Scrubber
- Control Panel
- Testing Kit

The advantages of this system are the production of Class A biosolids, and the lower energy use compared to other alternatives due to the generation of heat via chemical reaction. However, similar disadvantages exist for this system as with the other alkaline stabilization system:

- Continued lime use sustains the NWRF's reliance on chemical delivery and fluctuating costs.
- No redundancy for the system.
- This would introduce a new process for plant staff to learn and optimize.
- This option may increase polymer consumption to achieve the desired dewatered cake solids concentration, as well as a polymer product change.

The most significant shortcoming for the alkaline stabilization processes is that they all require continued use of lime at the Erie NWRF. Plant staff have indicated that their current dependence on lime for their solids stabilization process is not desirable. Due to the rapid growth expected in Erie and the increasing solids loading projections that accompany it, lime-based solids treatment systems are not practical long-term solutions, because increasing their capacity is difficult. For other stabilization alternatives, expansion is more easily accommodated by adding tank volume. However, this alternative relies on expanding capacity via longer and more frequent operation, which requires more staff resources to accommodate longer run times. When maximum capacity is reached, an entire new system must be purchased. For these reasons, this alternative is also eliminated from further consideration.

Preliminary Screening of Biosolids Stabilization Alternatives

A summary of the relative advantages and disadvantages of each biosolids stabilization alternative is shown below in Table 6-4.

Table 6-4. Preliminary Solids Stabilization Technology Comparison

Alternative	Advantages	Disadvantages
Aerobic Digestion	Well established technology	Prohibitive tank volume required
Anaerobic Digestion	Well established technology	High heat demand with no potential for offset via biogas generation
Solar Greenhouse Drying	Environmentally friendly, low energy	New technology, not well established
BCR CleanB	Modular design	High chemical use required, produces Class B biosolids
BCR Neutralizer	Cost competitive	High chemical use required
ATAD	Well established technology, no chemical use	High energy use

Table 6-4. Preliminary Solids Stabilization Technology Comparison		
Alternative	**Advantages**	**Disadvantages**
IGA	Diverts need for solids process expansion	Unlikely to find viable facility for agreement, complex transfer design
Hauling to Landfill	Diverts need for solids process expansion	High hauling costs, unsustainable
Lime Stabilization - Modify	Reduces capital costs of expansion	One-off design, functionality not guaranteed
RDP Lime Stabilization	Plant staff is familiar with lime stabilization	Continued lime use, Class B biosolids
Schwing Bioset	Plant staff is familiar with lime stabilization, produces Class A	Continued lime use

‘After completing the preliminary screening of biosolids stabilization alternatives, HDR and Town of Erie staff eliminated the following technologies from further consideration:

- Aerobic Digestion
- Anaerobic Digestion
- Solar Greenhouse Biosolids Drying with Supplemental Heat
- BCR CleanB
- Intergovernmental Agreement
- Hauling Biosolids to a Landfill
- Alkaline Biosolids Stabilization: Existing System Modification
- Alkaline Biosolids Stabilization: RDP Lime Stabilization
- Alkaline Biosolids Stabilization: Schwing Bioset System

The following stabilization systems were evaluated further with an economical and non-economical evaluation:

- BCR Neutralizer Alternative
- Autothermal Thermophilic Aerobic Digestion (ATAD)

The economical and non-economical evaluation of these alternatives are provided in Sections 6.6 and 6.7.

6.4.3 Solids Thickening Alternatives Evaluation

As part of the long-term biosolids stabilization study, it is important that ancillary equipment is given due consideration. If the Town of Erie decides to implement a new solids treatment process, the plant's existing rotary screen thickener will be detached from the dewatering screw press, and will likely operate as a standalone WAS thickening process. Therefore, this section evaluates alternatives for producing a robust and reliable WAS thickening system. The evaluated alternatives include keeping and reusing the existing FKC rotary screen thickener, and various new equipment options, including gravity belt thickeners, disc thickeners, rotary drum thickeners, screw presses, volute thickeners, and centrifuges. The following sections give overviews of each equipment, their primary thickening mechanisms, and their strengths and weaknesses. Lastly, a high-level comparison of the technologies is provided, along with a recommendation for next steps.

Reuse Existing

As discussed earlier in the existing solids system evaluation, the NWRF has an FKC rotary screen thickener that is used directly upstream of the FKC dewatering screw press. The unit's primary objective as it currently operates is to remove as much cold water from the WAS and lime slurry prior to the dewatering screw press, so that the temperature of the biosolids inside the screw press remains above 70 deg C for at least 30 minutes. However, this objective is no longer needed if the NWRF decommissions the FKC Class A system and installs a new stabilization technology. Therefore, the FKC rotary screen thickener can be repurposed for WAS thickening by detaching the unit from the dewatering screw press, and operating it as a standalone thickening process. Since the unit has the required capacity to meet 2028 total flow demands, it would be cost effective to reuse this piece of equipment.

There are various options for relocating the RST for WAS thickening. It could be relocated to the Thickener Room by the solids storage tanks. This room was originally intended to store thickening equipment, but is currently being used as a storage room for miscellaneous spare parts. As shown in Figure 6-23 below, this room is approximately 28' by 13'8", and the RST grating area, which accommodates the RST footprint, the polymer floc tank footprint, and room for O&M access, is about 21'4" by 9'4". Therefore, this unit could theoretically fit inside the Thickener Room; however, the polymer totes would need to be stored outside of the Thickener Room due to lack of space. Also, there would be no space for a second thickening unit in the room, so the building would have to be expanded to accommodate additional equipment. A roll-up door would have to be added as well, to facilitate moving equipment into the room.

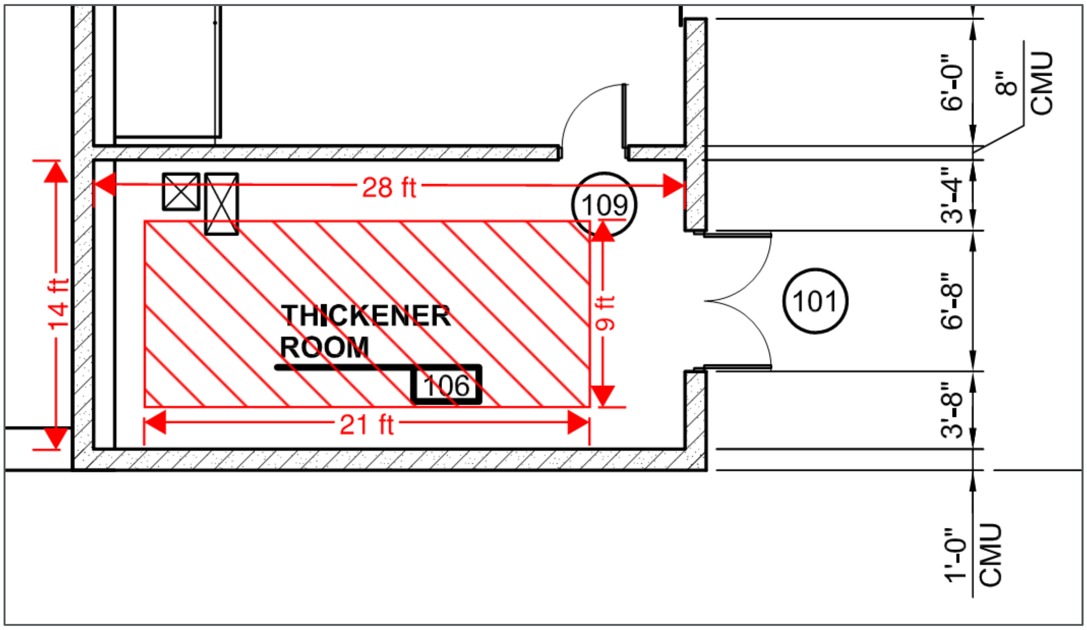


Figure 6-23: WAS Thickener Relocation to Thickening Room

Another option is to keep the rotary screen thickener in the Dewatering/UV Building, where it currently is. If the dewatering screw press is demolished and replaced with two smaller dewatering units, the Dewatering Building may be able to fit the polymer system, two thickeners, and two dewatering units. However, this is entirely contingent on the dewatering equipment technology selected. This alternative also requires more piping and pumping, since WAS will need to be pumped to the Dewatering Building, TWAS will be pumped back to the solids storage tanks or to the new biosolids stabilization process, and lastly stabilized biosolids will be pumped back to the Dewatering Building for dewatering.

The last option for relocating the existing rotary screen thickener is to move the unit to the new biosolids stabilization process building. For many of the biosolids stabilization alternatives discussed earlier, the new process would require a new building for housing ancillary equipment. Therefore, the existing thickener could be installed, along with a new thickening unit, in the new biosolids processing building. This would guarantee sufficient space for both thickening units, as well as the polymer system. The dewatering units and the associated polymer system could be kept in the Dewatering Building, which would also likely leave enough space for future units as well.

Gravity Belt Thickeners

Gravity belt thickeners have the advantage of being straightforward to operate, but can be difficult to maintain. The primary mechanism of liquids/solids separation is by gravity-induced filtration. One unit consists of a rotating belt on a steel table. Pre-conditioned sludge is distributed onto the woven nylon belt, and plows positioned just above the belt sort through the sludge and form small channels in which free water can drain through the belt.

GBTs perform best when thickening sludge that readily flocculates, such as WAS. The addition of polymer is necessary beforehand to guarantee proper coagulation, so solids are retained on the belt. After filtration, sludge is scraped from the belt and conveyed to a hopper, and free water is collected in troughs under the belt and transported to a filtrate collection system.

Figure 6-24. Sample Gravity Belt Thickener

The filtration and capture rate depend on several factors. A larger belt width provides more surface area for filtration, so the influent hydraulic and solids loading rates are congruently increased as well. The tension of the belt must be evenly distributed to avoid both pooling, and unfiltered sludge from reaching the hopper. Additionally, the nylon belt must undergo periodic washing by sprayers or booster pumps to prevent pore clogging and improve solids capture. The rotation speed of the belt may also affect the capture rate; in general, a slower rotation speed results in a slower filtration rate, but thicker sludge.

In general, gravity belt thickeners have the advantages of being robust and dependable, being straightforward to operate, and performing reliably once startup and optimization of the system is complete. However, the large footprint, wet atmosphere, and intensive maintenance needs are downsides to this equipment. Due to the existing space restraints at the plant for the thickening system, this alternative is unlikely to be the most viable option for the NWRF.

Disc Thickener

A disc thickener consists of an inclined cylindrical tank with an internal disc filter that separates the tank into two sections: one for thickened sludge holding and one for filtrate collection. This technology is similar to gravity belt thickeners because it removes water from WAS via gravity-driven filtration, but the shape and enclosed design makes it more suitable for applications in which a wet atmosphere is undesirable.

The tank inlet collects sludge that has undergone flocculation with polymer addition onto the disc filter. This filter often contains a perforated base disc covered with a micro-filter, which rotates around the inclined vertical axis. As the sludge is distributed onto the disc, suspended and self-adjusting plows form channels on the filter, which helps free water to drain through the filter more easily. A rubber scraper that connects from the center of the disc to the sludge outlet scrapes sludge from the filter and gathers it into the discharge system. A spray bar positioned between the sludge inlet and discharge backwashes the filter to keep pores from becoming clogged. After free water is released, it is collected into the lower portion of the tank unit, and ejected via the filter outlet.

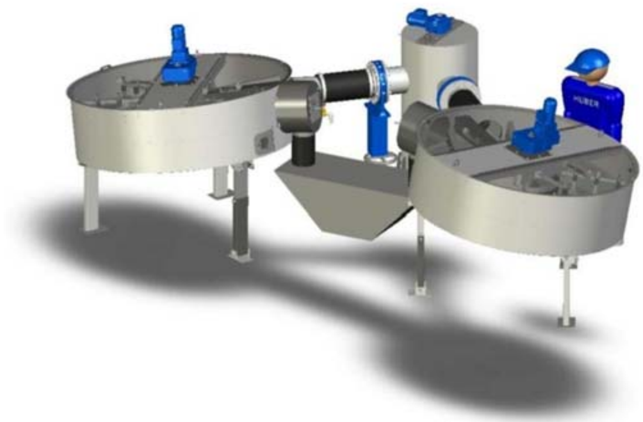


Figure 6-25. Huber Twin Disc Thickener

The disc thickener's performance depends on the polymer dose, backwash cleaning frequency, and the disc rotation speed. The site visit with HDR and Town of Erie staff to see BCR's Neutralizer installations showed Huber disc thickeners used for thickening sludge prior to reacting with chemicals in the storage tanks. Plant staff reported that the disc thickeners performed relatively reliably, but that there had been upsets when the disc thickener drums overflowed, spilling solids onto the floor. This indicates a temperamental operating system that must be finely tuned and optimized. The screens in the drums must be regularly washed to prevent clogging, and the loading rate of the thickeners must be optimized to prevent overflow. The BCR site visit is discussed further in Section 6.4.2.

The advantages to this equipment include the enclosed design and low energy consumption. However, this technology has fewer installations than others, and just one manufacturer, making it more difficult to gain familiarity with the equipment prior to selection. Additionally, this equipment requires a larger footprint than others, as well as containment to capture overflow. Due to the space requirements and operational challenges associated with this alternative, it is also unlikely to be the most viable option for the NWRF.

Rotary Drum Thickener

Rotary drum thickeners (RDTs) are a thickening technology that the NWRF staff is more familiar with, due to the existing RST unit at the plant. Although individual designs vary, the basic mechanisms of all rotary drum thickeners are the same. Polymer is injected into the feed sludge prior to entering the rotary drum thickener. The influent solids then enter a flocculation tank with a stainless steel wedge wire, perforated plate, or wire mesh drum. A mechanical mixer rotates the screen drum with a drum drive generally consisting of a gear-motor and synchronous drive belt. Internal and external spray bars spray through the screen to allow for suitable free water drainage, after which this water is discharged as additional filtrate. Radial flights inside the drum transport the thickened sludge to the discharge end, while free water flows through the drum screen openings and exits via a filtrate collection system.

Figure 6-26. Parkson Hycor Rotary Drum Thickener

This design accommodates a more rigorous handling of the sludge than seen in a gravity belt thickener, so filtrate collection can occur more efficiently. However, floc shear must remain low enough to prevent sludge particles from breaking and passing through the drum screen. Operators can control the capture rate by adjusting the feed rate, polymer dose, spray water cycling, and drum rotation speed.

The advantages of this technology are the reliable performance, high number of installations, the number of manufacturers that yield more competitive prices and performance, the availability of spare parts, and the NWRF staff's familiarity of the technology. However, should the Town decide to install another RDT, a more detailed assessment of various manufacturers is necessary to narrow the selection to the most appropriate equipment fit for the NWRF. Evaluation criteria should include thickening performance, cost, polymer use, energy use, and reliability.

Screw Press

The screw press is another technology that the NWRF staff is familiar with; however, a thickening screw press is significantly different than the dewatering screw press Erie currently has. A thickening screw press does not typically use a boiler for steam injection, nor does it have the 30 minute retention time requirement. These make thickening screw presses typically smaller than the FKC dewatering screw press. In general, the screw press is a slow-moving thickening or dewatering technology that can either be horizontally fitted or inclined. Major elements of the thickening section of the design include a sludge inlet, the screw drive, a rotating screw shaft inside a cylindrical sieve, an enclosed compartment for filtrate collection, and a thickened sludge outlet pipe.

The sludge is pre-conditioned with polymer addition before entering the main compartment, where initial filtration occurs by gravity. As the conical screw shaft transports the sludge further down the compaction chamber by slow rotation (0.2 – 1.5 rpm), the spacing between screw flights decreases so sludge is pressed against the sieve surface and more free water passes through. The pressing force can be adjusted by varying the position of the cylindrical filter. At the end of the compaction chamber, thickened sludge is subjected to a pneumatic counter-pressure cone at the sludge discharge location. The rotating screw pushes the sludge past the cone into the discharge collection system. The filtrate is collected by the outer compartment shell, and released via a filtrate outlet pipe.

Figure 6-27. Huber Screw Press Thickener

In some designs, steel brushes fitted to the screw edge continuously clean the filter, and periodic cleaning occurs by backwashing with high-pressure water sprayers outside the sieve. However, some screw presses require manual periodic cleaning. The capture rate and the total solids output vary by rotation speed, influent sludge quality, and the position of the pressure cone.

Screw presses have the advantages of performing reliably, operating within an enclosed design, and having relatively low energy usage. Although there are fewer thickening screw press installations than others, St Vrain Sanitation District (SVSD) has two Huber screw press thickening units at their WWTP that is conveniently located close to the Erie NWRF. Furthermore, these units provide WAS thickening for their ATAD biosolids stabilization process. Therefore, data and input concerning their operation and performance in relation to ATAD can be obtained from SVSD prior to final selection.

Volute Thickener

The volute thickener design operates on similar principles seen in a rotary drum thickener, but differs by the materials used for solids capture. It is suitable for applications requiring complete automation and little maintenance. Additionally, volute thickeners prevent clogging by utilizing a filtration system with moving parts; as a result, there is no need for an external cleaning program and wash water use is significantly reduced.

Figure 6-28. PWTech Volute Thickener

WAS is dosed with polymer before entering a flocculation tank, where solid particles agglomerate and allow for the separation of solids and free water. The sludge then overflows to a cylindrical drum with a large Archimedean screw inside. The walls of the drum are formed by fixed plastic rings separated by spacers. Moving plastic rings with a slightly narrower width and smaller inside diameter are located between each fixed ring, and the screw shifts these rings as it rotates. This configuration of rings produces small gaps which allow free water to pass through to a collection and discharge system. The thickened sludge is pushed down the length of the drum by the rotating screw and exits via a discharge outlet at the opposite end.

The advantages of volute thickeners are that they are energy efficient and require less wash water usage than other alternatives. However, there are few installations in the US, and PWTech is the only manufacturer of the technology. The Greeley WWTP recently installed two volute thickeners for WAS thickening at their plant, but they have not been operating for enough time to give reliable data concerning their performance and dependability.

Centrifuge

Centrifuges are a good option when complete automation and small footprint are desirable, but they can be cost prohibitive and energy intensive. The basis of sludge thickening in this technology is an induced centripetal force that causes solids to settle faster than in a clarifier or gravity thickener. Two main components in a centrifuge include a bowl with both a cylindrical and conical portion, and an internal scroll conveyer. The bowl is fitted horizontally, and spun about an axis at a high rotational speed (at least 1500 rpm) to create a centripetal force that presses solids against the bowl wall. The scroll is spun at a speed 10 – 20 rpm faster or slower than the bowl, which generates a differential speed. The solids are transferred by the scroll to the conical end of the centrifuge, while water is released at the other end.

Figure 6-29. Centrisys Centrifuge Thickener

Factors affecting centrifuge performance include bowl dimensions, polymer dosage, differential speed between the scroll conveyer and the bowl, and the scroll configuration. The high level of process automation within the centrifuge design has required most units to be pre-equipped with variable instrumentation settings based on influent and discharge measurements. Centrifuges typically produce effluent sludge with higher total solids concentrations than seen with other sludge-thickening technologies.

The benefits of centrifuges are that they provide reliable performance after startup and optimization of the equipment is complete, they have a compact footprint, they require little operator attention due to robust automation, and they often provide thicker solids than other alternatives. However, centrifuges are typically more expensive, require more energy than other options, and they can have temperamental startup and optimization procedures.

Preliminary Screening of Thickening Alternatives

Table 6-5 below gives a high-level comparison of the thickening technologies discussed above. In general, each technology is fairly well-established, and has the capacity to perform effectively. However, there are small differences between them that make some alternatives more suitable for the Erie NWRF than others. Smaller footprint equipment is preferable for Erie, since the WAS thickening system may be relocated to an existing building within the plant. Additionally, thickening technologies that require less operator attention are also desirable to NWRF staff.

Table 6-5. Preliminary Thickening Technology Comparison

Parameter	Disc Thickener	RDT	Screw Press	Volute Thickener	GBT	Centrifuge
Strengths	Low energy consumption	Well proven technology, ease of operation	Low energy consumption	Low energy/water usage	Low energy consumption, simple to operate	Low polymer usage, compact footprint

Table 6-5. Preliminary Thickening Technology Comparison

Parameter	Disc Thickener	RDT	Screw Press	Volute Thickener	GBT	Centrifuge
Weaknesses	Proprietary technology, difficult operation	Higher polymer usage than current dose	Limited applications in WAS thickening, large footprint	Newer technology, fewer installations	Large footprint, open to wet environment	High energy usage, high capital costs
Solids Capture[a]	98%	98%	97%	97%	98%	98%
TWAS Concentration[a]	6%	5 – 7%	4 – 9%	4 – 10%	4 – 13%	4 – 10%
Polymer Use Expected (lb active/DT)[a]	11 – 13	7.5	6 – 10	8 – 15	13	2 - 5
Energy Use (HP)[a]	1.25	3	1.5	4	8	150
Relative Unit Footprint[a,b]	+	0	+	-	++	0

[a] These values are based on a compilation of data provided by various manufacturers, as well as *Wastewater Engineering: Treatment Disposal Reuse, 3rd edition* by Metcalf and Eddy for comparison purposes. Specific equipment models may vary from the values provided in this table.
[b] The + symbol denotes a larger footprint compared to other alternatives, 0 denotes an average-sized footprint, and the - denotes a smaller than average footprint.

Based on this comparison and analysis, HDR recommends that the NWRF retain the existing RST, and detach it from the FKC dewatering screw press for use as a standalone WAS thickening system. Furthermore, a second thickening unit should be purchased for system redundancy.

HDR recommends the following steps for final selection of a thickening unit:

- Confirm selection of the plant's biosolids stabilization technology, and obtain input from MFR regarding desired total solids concentration in stabilization system feed.
- Perform pilot testing with available technologies to confirm their performance with the NWRF's WAS material.
- Conduct site visits as necessary to familiarize staff with various thickening technologies.
- Determine the location and layout of thickening units during the next expansion project design. Consider equipment footprints.

6.4.4 Solids Dewatering Process Alternatives Evaluation

Similar to the WAS thickening technology evaluation, it is important that the dewatering equipment technologies are evaluated as well. The new or altered biosolids stabilization process at the NWRF will result in an altered sludge product being sent to the plant's dewatering process. Therefore, various dewatering alternatives are evaluated in this section to determine the most appropriate technology for the NWRF. Evaluated alternatives include keeping the existing FKC dewatering screw press, centrifuges, and belt presses. The following sections give overviews of each equipment, their primary dewatering mechanisms, and their strengths and weaknesses. Lastly, a high-level comparison of the technologies is provided, along with a recommendation for next steps.

Reuse Existing

The first solids dewatering alternative is to reuse the NWRF's existing FKC dewatering screw press, but to use it exclusively for biosolids dewatering. The screw press would be detached from the RST, provided a separate polymer system, and operated without steam addition. The screw press speed and operational settings would likely need to be altered to optimize the unit for just dewatering. As mentioned earlier, the unit is currently nearly at maximum capacity. However, the new or altered biosolids stabilization system may potentially reduce biosolids volume, or eliminate the need for lime. Both outcomes would result in the dewatering screw press gaining some time before its maximum capacity is reached. Therefore, this alternative could be considered for an interim solution until the Town has the appropriate resources to purchase a new dewatering system. However, this would mean that the system would remain without redundancy.

The advantages of this alternative include reuse of existing equipment, and its potential as an interim system. Challenges associated with this alternative include the risk that the FKC screw press will not perform as desired with an altered sludge product, and that the size of the dewatering screw press may render it difficult to fit additional equipment in the Dewatering Building, due to the size of the equipment.

Centrifuge

Centrifuges can be used for both dewatering and WAS thickening. An overview of centrifuge operation principals was described in Section 6.4.3, for WAS thickening. Centrifuges work in a similar manner for solids dewatering.

Centrifuges are an enclosed process, have high hydraulic throughput, and have a small footprint. However, energy use is relatively high due to the high rotational speed of the bowl and the process must be closely monitored. Centrifuges do have the potential to produce a thicker sludge concentration at a lower polymer use than other technologies. Figure 6-30 presents a dewatering centrifuge.

Figure 6-30: Sample Dewatering Centrifuge

Belt Press

Belt filter presses (BFPs) are widely used in the U.S. for solids dewatering. The belt filter press uses two or more serpentine belts and a series of rollers to mechanically filter and separate moisture from stabilized solids. The BFP is typically not enclosed to allow the operator to visually inspect the operation as the basis for making adjustments to the speed of the machine and incoming sludge feed rate. This results in the need for ongoing housekeeping maintenance and also increased fugitive odors and larger HVAC system. BFP's also require a large footprint and high ceiling due to their size, and have high belt wash water demand. Capital costs for equipment are typically low, however building infrastructure and ancillary systems add to the overall cost. Maintenance costs are relatively high due to the periodic replacement of belts. The equipment requires greater operator attention when compared with rotary and screw presses. Figure 6-31 shows a belt filter press.

Figure 6-31: Sample Ashbrook Belt Press

Preliminary Screening of Dewatering Alternatives

Table 6-6 below provides a high-level comparison between each of the evaluated dewatering technologies.

Table 6-6. Preliminary Dewatering Technology Comparison

Parameter	Screw Press (Reuse)	Belt Press	Centrifuge
Strengths	Uses existing equipment	Straightforward operation, reliable performance	Low polymer usage, compact footprint
Weaknesses	Expected performance with altered sludge unknown, footprint	Requires more maintenance, odor control necessary	High energy usage, high capital costs, temperamental optimization
Relative Dewatered Solids Concentration	Unknown	+	+
Relative Energy Use	0	-	++
Relative Unit Footprint	+	0	+

Due to the number of items that must be decided before a final dewatering technology decision can be made, HDR recommends the following next steps towards selection:

- Confirm selection of the plant's biosolids stabilization technology, and obtain input from MFR regarding which technology it performs best with.
- Perform pilot testing with available technologies to confirm their performance with the NWRF's biosolids.
- Conduct site visits as necessary to familiarize staff with various dewatering technologies.
- Determine the location and layout of dewatering units during the next expansion project design.

6.4.5 Polymer System Optimization

It is expected that the new dewatering process will require an updated or new polymer system. Currently, the NWRF's RST thickener has an associated polymer system, but the dewatering screw press does not have a separate polymer system, since the thickened WAS is fed directly into the screw press. Therefore, the objective of this section is to discuss methods for optimizing both the plant's existing polymer system for thickening, as well as the new polymer system for dewatering.

The purpose of a polymer system is to efficiently and economically condition the liquid biosolids feed prior to dewatering to achieve greater water release, higher cake solids, and improved centrifuge dewatering return quality. Polymer is added to achieve the highest possible solids capture rate in the dewatering or thickening unit, ultimately decreasing the amount of water hauled, thus, decreasing the hauling cost. The polymer system evaluation consists of the following:

- Type of polymer – dry, emulsion, or dual
- Use of aging tanks to improve activation of both dry and emulsion polymers
- Storage
- Delivery and metering system

Polymer Type Consideration

Polymer can be provided in either dry or liquid form, where dry polymers are 100 percent active, liquid dispersions are up to 50 percent active, and emulsions up to 40 percent active. The wetting and mixing equipment used for dry and liquid polymers are different. In humid climates, dry polymers potentially clump and start to activate while in storage due to the moisture in the air.

Not all polymers behave the same, and selection should factor in the type of solids being dewatered (waste activated solids vs waste activated solids and lime) and the dewatering technology (centrifuge vs screw press vs belt filter press). Due to the high shear condition inside a centrifuge, typically cross linked polymers perform better by creating a stronger floc. In addition, cross linked polymers have a high cationic charge and molecular weight which increases the strength of the bond. Dry polymers do not have the cross linking resulting in a weaker floc strength. This results in a wetter cake and reduced centrifuge dewatering return quality. The benefit to a dry system is cost. Typically dry polymers are 40 percent less expensive compared to an emulsion system.

Figure 6-32 schematically shows the cross linking differences between a dry and emulsion polymer. Figure 6-33 shows the floc quality difference between polymers; Polymer #1 has no distinguishable free water or floc structure, and Polymer #2 allows for free water to drain.

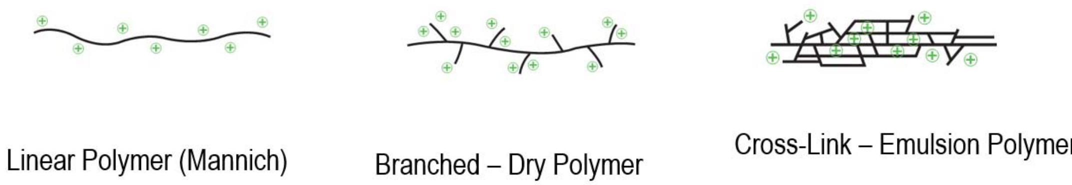
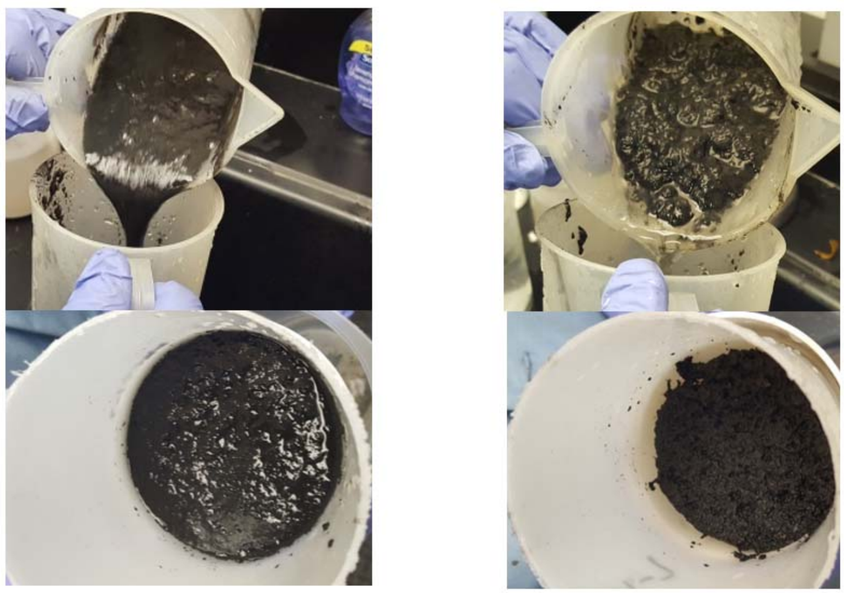


Figure 6-32: Schematic of Cross Linking Differences between Polymers



Polymer #1 – Bench Floc & Buchner Funnel Test | Polymer #2 – Bench Floc & Buchner Funnel Test

Figure 6-33: Floc Quality Differences between Polymers

Additionally, solids that are difficult to dewater, such as solids from biological phosphorus removal with ATAD digestion, show low conditioning performance with dry polymers. However, the addition of ferric to the solids prior to dewatering has shown to reduce the impact of biological phosphorus removal.

The price of emulsion polymer in the Rocky Mountain region is approximately $1.30/lb. (40 percent active), whereas dry polymer is priced at $2.00/lb. (100 percent active). Per dry ton of solids, emulsion polymer costs approximately $136/DT and dry polymer approximately $84/DT. For cost efficiency, dry polymer should be considered during the summer months when solids are typically easier to dewater. It is recommended the Erie NWRF test dry polymers with a polymer manufacturer before investing in equipment to ensure a dry polymer will work with this specific sludge. Emulsion polymer, regardless of the cost, will be included as the base option for the NWRF thickening and dewatering system with the dry system evaluated as an add-on unit.

Polymer Mixing and Aging Considerations

Options for mixing and aging include the use an inline mixer, mixing tanks, or aging systems. The advantage of using the inline mixer is space savings. However, including aging tanks allows for 100 percent polymer activation, which optimizes polymer consumption. Inline mixers can typically only activate polymer to 75-95 percent. Figure 6-34 displays the impact that mixing has on the viscosity of polymer, which is an indicator for polymer activation. Higher viscosity indicates that polymer is more activated.

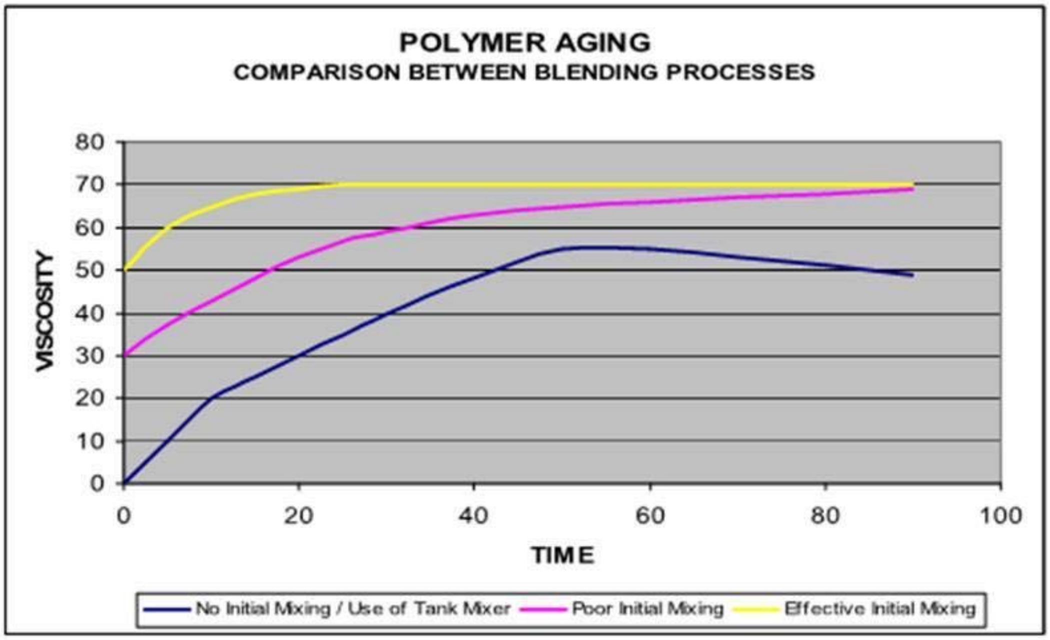


Figure 6-34: Polymer Aging Time for Various Mixing States

Based on 2038 average conditions, the addition of aging tanks can save Erie approximately $20,000 annually as noted in the calculation below.

- The NWRF is expected to produce a maximum month value of 18,300 dry-lb/day, without lime, or 9.15 DT/day. Typical polymer consumption for dewatering presses varies between 25 – 35 lb/dry-ton. For the below calculations, the worst –case scenario polymer consumption of 35 lb/dry-ton is used. With a polymer price of $1.30/lb. for emulsion polymer, the total cost of polymer consumption for an aging tank system with 100 percent polymer activation is:
  - 35 lb-poly/DT * 9.15 DT/day * 365 day/yr * $1.30/lb-poly / 40% active = $380,000 per year.
- If only an inline mixer is used to activate the polymer it results in 95 percent activation (the possible highest activation). The total cost of polymer would be:
  - 35 lb-poly/DT / 0.95 activation * 9.15 DT/day * 365 day/yr * $1.30/lb-poly / 40% active = $400,000 per year, an increase of $20,000/year

For an aging system, two 2,000 gallon tanks with level transmitters, controls, and feed pump skids costs approximately $25,000. Mixers can also be placed in aging tanks to prevent fish-eyes and stratification for an additional $10,000. With all components and an assumed 95 percent activation, an aging tank system can be paid for in a couple years, with $20,000 in emulsion polymer savings per year thereafter. Figure 6-35 shows an example of a polymer aging tanks system.

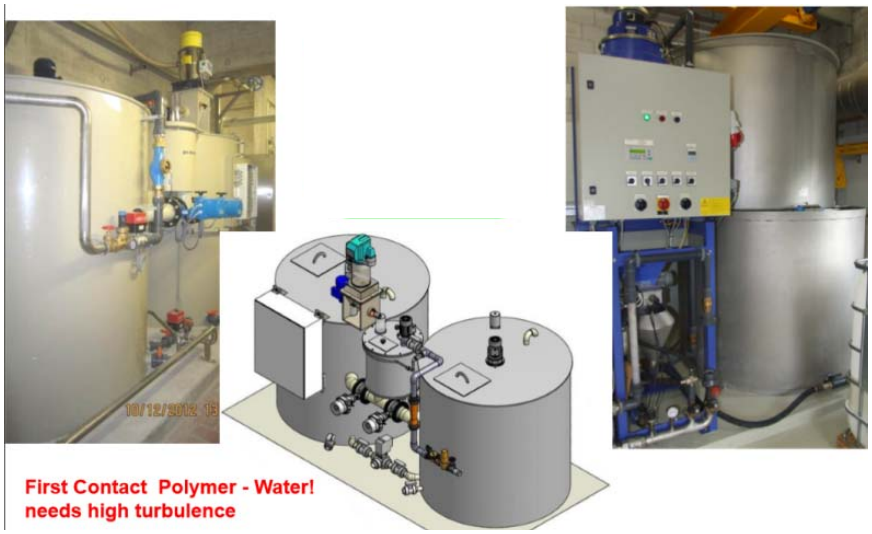


Figure 6-35: Example Aging Tanks for a Dewatering Polymer System

Based on the payback, it is recommended that the new polymer system include aging tanks. Including the aging tank system provides flexibility if a dry polymer system is added.

6.5 Mineralogical Controls and Recovery

Some biosolids stabilization technologies, including ATAD, have been reported to produce the deposition of a mineral called vivianite in the system. The following sections discuss the formation potential of struvite/vivianite in more detail, and potential control methods.

6.5.1 Deposition of Minerals

Struvite

Struvite is a phosphate mineral with the chemical formula $NH_4MgPO_4 \cdot 6H_2O$, comprised of magnesium, ammonium, and phosphate ions. To form, all three compounds must be present. If just one of the compounds is under the maximum soluble concentration, struvite will not form. Additionally, struvite is more soluble at lower pH values, meaning that struvite is more likely to precipitate at higher pH values. In wastewater treatment, struvite is most often found in digesters, dewatering liquid return such as centrate or pressate, and in biosolids. Figure 6-36 shows a diagram of the solubility product (Ksp) dependent on pH.

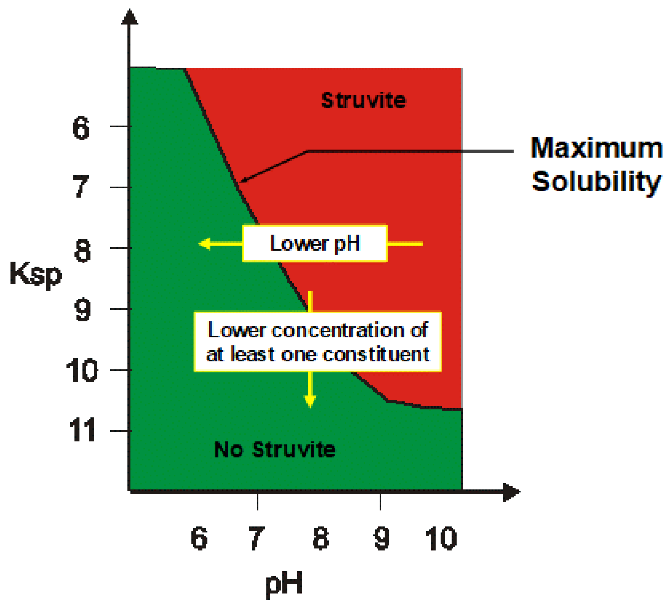


Figure 6-36: Struvite Solubility at Variable pH

ATAD reactors operate at a high temperature (140 degF) and high pH (8.2). Assuming that ATAD reactors contain the same ammonia and phosphorus concentrations as the dewatered pressate, the ATAD system should have the potential to form struvite. However, struvite is a “hydrolyzed” mineral, meaning that water molecules must be in a steady-state for struvite to form. Because the ATAD reactors are at a high temperature, approximately 140 DegF, the struvite remains in a soluble form.

For the SNDR reactor, the temperature drops below 120 Deg F, providing an opportunity to form struvite. However, the SNDR tank operates at a pH of 6, preventing the formation of struvite, as shown in Figure 6-36.

The biggest risk for struvite formation is the heat exchanger between the ATAD and SNDR tanks that has the same pH level as the ATAD reactors, and lower temperatures of 120 DegF. Based on discussions with TPS, a regular maintenance procedure of recording and documenting the pressure, flow rate, and temperature of the solids going through the heat exchanger should be monitored. Changes in pressure and flow rate from previous records could indicate build-up of struvite in the piping system. When it is determined that struvite is forming in the heat exchanger, contents from the SNDR can be recirculated through to re-solubilize the material.

Though the ATAD and SNDR systems have a low potential to form struvite, it is recommended that the phosphorus be removed from the dewatering pressate to protect downstream equipment and reduce the recycle phosphorus load on the liquid treatment system. It is recommended an iron chemical, such as ferric chloride or ferric sulfate, be injected after the SNDR tank and prior to the dewatering system.

Vivianite

Vivianite is a hydrated iron phosphate mineral with the chemical formula $Fe^{2+}(PO_4)_2 \cdot 8H_2O$, comprised of iron and phosphate compounds. Like struvite, all compounds must be present in order for vivianite to form, and the solubility of vivianite is higher at lower pH values. Additionally, vivianite solubility is slightly affected based on temperature. At higher temperatures, the solubility product is slightly lowered.

For the Erie NWRF, vivianite would only form if ferric coagulant is used upstream of solids treatment process. Since struvite is unlikely to form in the ATAD reactors, there should be no reason to add ferric upstream of the ATAD reactors, thus minimizing the risk of vivianite formation in the system.

6.5.2 Struvite Recovery

Another option to the addition of ferric prior to dewatering is the recovery of struvite from either the digested solids, dewatering pressate return line, or the WAS line. Various technologies exist including:

- AirPrex®: Struvite harvesting on digested solids line
- Ostara®: Struvite harvesting in pressate liquid return line
- NuReSys®: Struvite harvesting in digested solids and/or pressate return line

Figure 6-37 and Figure 6-38 display the process flow diagram and specific photos of the AirPrex® system for struvite recovery as an example of how these systems would integrate into the NWRF.

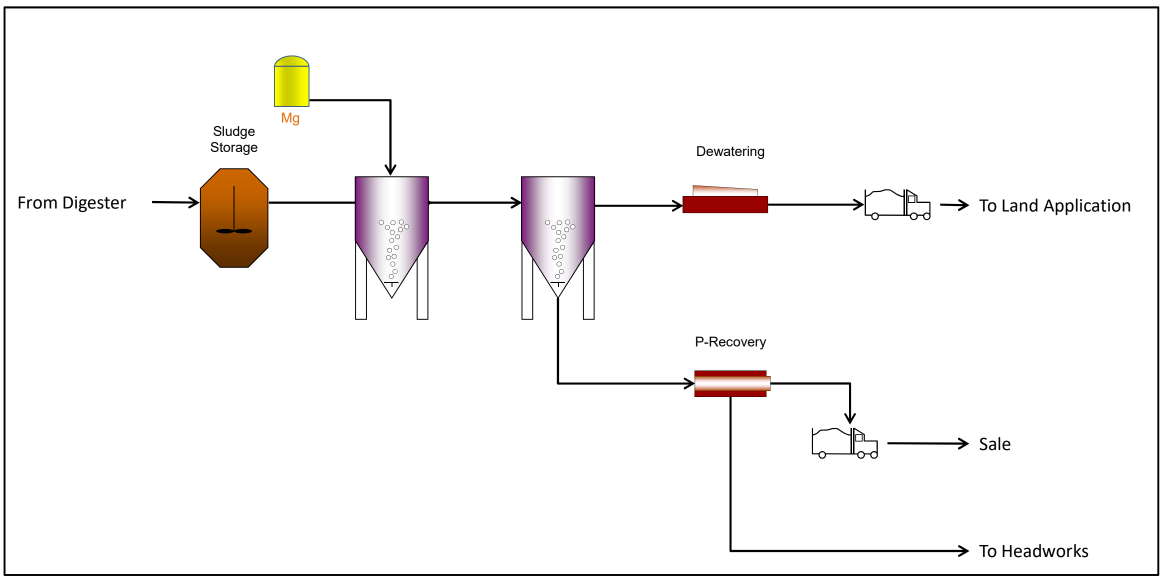


Figure 6-37: AirPrex Process Schematic with Struvite Recovery

Airprex Reactor at the Facility in Berlin, Germany

Recovered Struvite from the Berlin Airprex System

Figure 6-38: Photos from the AirPrex Facility and Product

Due to the ATAD/SNDR system, ammonia in the digested sludge or pressate is relatively low at approximately 300 mg/L. Therefore, struvite recovery systems may not provide adequate benefit when compared to an installation cost of $800,000.

6.6 Cost Evaluation of Narrowed Alternatives

Table 6-7 below provides a summary of the cost estimates for each of the narrowed biosolids stabilization alternatives.

Table 6-7. Total Anticipated Project Costs of Solids Stabilization Alternatives

Alternative	Total Anticipated Project Cost (TAPC)
ATAD	$15,202,000
BCR Neutralizer	$9,338,000
Keep Existing	$7,814,000

For each of these alternatives, the total anticipated project cost was determined for 2028 design conditions. However, the Keep Existing alternative assumes that only one new FKC Class A system is added, which, as noted earlier, would not technically bring the solids handling system all the way to 2028 total flow demand conditions; the capacity of the system would be 12,240 lb/day, as opposed to the required 14,040 lb/day. However, since this alternative would likely be considered an interim solution, the cost analysis assumed the addition of only one system.

Overall, the ATAD system shows the highest capital cost, followed by the BCR Neutralizer, and then the Keep Existing option. In order to further evaluate the relative cost savings of the Keep Existing alternative, 10 year net present value (NPV) calculations were performed for the Keep Existing and ATAD alternatives. The results of this analysis are shown below.

Table 6-8. NPV Analysis for Keep Existing and ATAD Alternatives

Alternative	Total Anticipated Project Cost (TAPC)
ATAD	$15,202,000
Keep Existing	$7,814,000
Alternative	**10 Year NPV**
ATAD	$23,947,000
Keep Existing	$23,659,000
Alternative	**20 Year NPV**
ATAD	$45,334,000
Keep Existing	$65,191,000

This analysis showed that although the initial capital costs of the ATAD system are significantly higher than the Keep Existing option, the total net present value costs begin converging over time. This is due to the continued use of lime, and the higher hauling costs associated with keeping the existing system. Additionally, after 10 years of keeping the existing system, substantial improvements, including two new FKC Class A systems with all ancillary equipment, further building expansion, and improvements to the solids storage tanks would be required to meet 2038 conditions.

6.7 Non-Economic Evaluation of Narrowed Alternatives

The non-economic evaluation plays a key role in the selection process. It captures the criteria that are not associated with cost, but that are important for ensuring that the new biosolids stabilization alternative is implemented as seamlessly as possible at the NWRF.

The non-economic evaluation was based on scoring of each criterion, applying a weighting factor, and calculating a “total benefit” for each alternative. The weighting factor is determined based on the relative importance of each criteria. The criteria that are more important to NWRF were given a higher weighting factor than those that are deemed less important. The resultant “total benefit” value, coupled with the economic analysis, provides an overview of the relative costs and benefits for each alternative. Following is a description of the non-economic criteria, specific to solids stream treatment system.

Operator Attention

An alternative is rated high for operator attention if the technology operates efficiently on set-points that do not need frequent tuning. The staff at NWRF prefers equipment that is easy to operate with minimal control complexity. Automated systems are preferred while systems that require operators to be present to adjust settings are scored lower.

Operator Familiarity

Equipment the operators are familiar with receives a higher score. Changing to a new type of equipment may be beneficial for other categories, but would take additional operator attention while staff becomes familiar with the equipment.

Maintenance Requirements/Complexity

Ease of maintenance and timeline of repairs are important to NWRF staff. Equipment with minimal regular maintenance requirements is preferred. An alternative with an equipment layout that provides good equipment access receives a higher score. Equipment that requires excessive downtime or parts to be sent out to be machined receives a lower score.

Flexibility to Meet Future Flows and Loads Needs

An alternative is rated higher if it has flexibility to meet the future flows and loads requirements. A process that is easily expanded, where equipment can easily be added to increase capacity of that process.

Footprint

Due to potential space constraints of the site to meet distant future flow/load requirements, an alternative was rated higher if it was more efficient with footprint.

Implementability

Implementability is how easily the alternative can be constructed and incorporated into the existing systems. Technologies that require more complicated retrofits or more time for permitting and approval received lower scores than those that can be installed using the existing layout and equipment at the NWRF.

Redundancy

An alternative that provides greater overall redundancy and ability to take one train offline for maintenance was rated higher.

Robustness/Long-Term Sustainability

The robustness criterion evaluates the proven lifespan of equipment. Technologies that have been used for decades and are proven to meet requirements similar to NWRF's receive a higher score. Technologies that are emerging in the domestic market or are reported to be more troublesome than others were scored lower.

Safety

Alternatives that introduce greater health risks during operation and maintenance to the NWRF staff received lower scores than those that have lower risk of accidents.

For the non-economic evaluation, HDR compared the solids stream alternatives based on the criteria listed above. Each criterion was assigned a rating from 1 to 5, with 5 being the highest (best) rating attainable. The ratings were then added and divided by the total possible score to define a weighted score for each alternative. The ratings presented in this chapter were developed by HDR and presented to the Town of Erie staff to confirm agreement with the results.

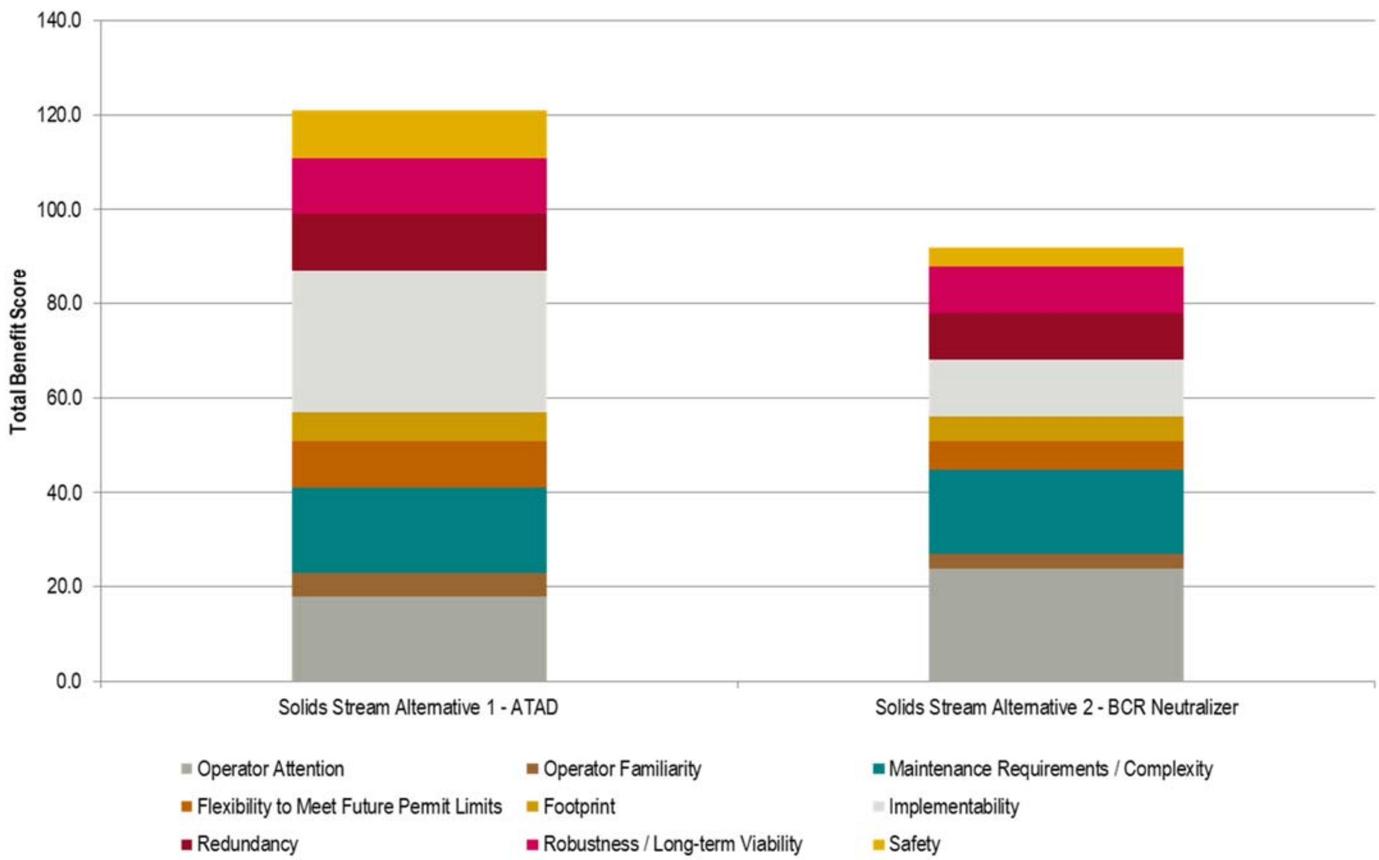


Figure 6-39: Non-Economic Evaluation of Narrowed Alternatives

As shown, the ATAD alternative received the highest non-economic score, followed by BCR's Neutralizer for Class A solids option. Although the BCR technology had higher scores for operator attention, ATAD received the highest scores in implementability, redundancy, safety, and flexibility to meet future permit limits. Since ATAD is already established as a PFRP accepted by the EPA, the risk of the NWRF encountering issues producing Class A biosolids in the future due to changing regulations is lower than for BCR's Neutralizer. This also allows for better implementability of ATAD, since permit approval is more straightforward than for the other alternatives. It also can be constructed as a standalone system, minimizing impacts to ongoing operations as it is constructed.

6.8 Summary of Solids Stream Recommendations

Based on the solids system short-term and long-term biosolids evaluations provided throughout this chapter, HDR recommends the following solids system improvements for inclusion in the next expansion project:

- Include primary priorities captured in the existing system capacity evaluation, excluding those items related to the FKC Class A system:
  - Solids dewatering pump
  - WAS thickening unit
  - Lean-to structure for solids storage
  - Distribution screw for dewatered solids
  - Solids storage tank lining
- Implement ATAD as new biosolids stabilization process for Class A biosolids at Erie NWRF. Install a new biosolids stabilization facility sized for 2028 conditions, with two ThermAer tanks, one SNDR tank, a biofilter, building space for ancillary equipment, and leave room for expansion to 2038 conditions.
- Detach FKC rotary screen thickener from dewatering screw press and use as standalone thickening system. Install a second thickening unit for redundancy.
  - Install the new thickening system in the existing Dewatering Building, if there is enough space for both the thickening and dewatering systems in the Dewatering Building without alterations. Thickened WAS would be pumped to the new ATAD facility.
  - If there is not enough room in the Dewatering Building for both the thickening and dewatering systems, install the WAS thickening system in the new ATAD facility.
  - The exact thickening technology should be further evaluated during the next expansion project predesign.
- Demolish FKC dewatering screw press and install a new dewatering system with redundant units in the Dewatering Building. The dewatering technology selection should be further evaluated during the next expansion project predesign.
- Install new polymer system with mixing/aging tank for emulsion polymer. Consider a dry polymer system for use during the winter.

Contents

7 Existing Facility Site Improvements 7-1
7.1 Introduction 7-1
7.2 Objectives and Purpose 7-1
7.3 Maintenance Building 7-1
7.4 Equalization Basin 7-2
7.5 Odor Control 7-2
7.5.1 Odor Control Technologies 7-3
7.6 Influent Flow Measurement Improvements 7-9
7.7 Effluent Flow Measurement 7-10
7.8 Wet Well Inspection and Coating 7-11
7.9 Non-potable Water System Improvements 7-11
7.10 Dewatering Polymer Improvements 7-12
7.11 Solar Panels 7-13
7.12 Economic Evaluation 7-14
7.13 Recommendations 7-15

Tables

Table 7-1. Treatment of H2S with Activated Carbon Products 7-6
Table 7-2: Opinion of Probable Construction Cost 7-15

Figures

Figure 7-1. Examples of Inorganic Media for Biofiltration 7-4
Figure 7-2. Example of Organic Media for Biofiltration 7-4
Figure 7-3. Example Biotrickling Filter System 7-5
Figure 7-4. Example Activated Carbon Foul Air/Odor Control System 7-6
Figure 7-5. Example Chemical Scrubber System 7-7
Figure 7-6 Location for Odor Control Activated Carbon Filters in Headworks Facility 7-8
Figure 7-7 Example Activated Carbon Intake Filter 7-9
Figure 7-8 Effluent Parshall Flume Location 7-11
Figure 7-9 Existing Dewatering Polymer Transfer System 7-13
Figure 7-10 Example Polymer Design 7-13

This page is intentionally left blank.

7 Existing Facility Site Improvements

7.1 Introduction

The North Water Reclamation Facility is the Town of Erie's wastewater facility, designed to treat 1.95 MGD of wastewater. In anticipation of population growth in the area, the Town is planning an expansion which will include liquid stream and solids stream improvements, described in detail in Chapters 5 and 6 respectively of this Master Plan. As part of the expansion, additional miscellaneous work will be performed to improve the working environment and treatment capability of several processes. This miscellaneous work is described in depth within this chapter.

7.2 Objectives and Purpose

The purpose of this chapter is to provide technical expertise and cost estimates for resolving issues with miscellaneous sections of the treatment plant. This includes evaluation and recommendations for the following items:

- Maintenance Building - Assess the need for a new Maintenance Building.
- Equalization Basin – Assess the need, advantages and challenges of adding an Equalization Basin, its value to the NWRF, process details of the system, capital and operating costs, and operational considerations.
- Odor Control Investigation and Recommendations - A detailed odor control improvements plan. Long-term and short-term solutions will be provided to the Town for evaluation and determination of any improvement needs. Odor control technologies will be reviewed and assessed with a concluding recommendation on what, if any, system is recommended. The conclusions and recommendations of the Biosolids Stabilization Study will be incorporated with any odor control recommendation made.
- Dewatering Polymer System – Provide recommendations for optimizing polymer delivery and exchanging totes at the NWRF
- NPW Pressure at Secondary Clarifiers – Provide recommendations to improve the pressure at the yard hydrant near the secondary clarifiers
- Connect Irrigation to NPW system – The Town is investigating installing an irrigation system at the NWRF.
- Flow Monitoring at MH Upstream of Headworks – Regulatory agencies have requested a more accurate flow monitoring system at the NWRF for influent flows.

7.3 Maintenance Building

Currently, the NWRF is not equipped with a maintenance building and the existing WAS Thickening building is used as a make-shift location for storage and maintenance of plant equipment. A new maintenance building would allow the existing WAS Thickening space to be cleared and used as originally intended, as well as provide a suitable work environment for O&M activities. A focus on its location and design details can turn this investment into a highly utilized part of the Facility.

During the development of this project, the Town of Erie discussed providing a packaged maintenance building through a separate project at a later date.

7.4 Equalization Basin

The Town of Erie requested the evaluation of an equalization basin prior to the Headworks Building. This section evaluates the benefits and drawbacks of an equalization basin at the NWRF.

Equalization (EQ) basins are utilized to reduce diurnal variations of flows to wastewater treatment plants, and are sometimes used in systems with combined sewers or high incidences of I&I. Additional benefits of a properly sized EQ basin include:

- Stabilization of variable conditions, such as snow and storm events;
- Stabilization of diurnal flows;
- Reclaim secondary treatment capacity;
- Reduce ammonia peaking issues;
- Reduce power peaking;

There are also many challenges with adding an EQ basin to the treatment plant. Providing a new EQ Basin would introduce an entirely new process to the treatment train which requires operation and maintenance. New blowers, mixers, and pumps would be required. Odors are continuously an issue with EQ basins since they are open to atmosphere. After use of an EQ basin, the basin requires cleaning with non-potable water to minimize vector attraction and odors. EC Basins are also a large capital cost and require regular operational costs and time. With a 2038 average daily flow of 4.56 MGD, as calculated in Chapter 3 of this Master Plan, and a peaking factor of 2.0, a minimum of 300,000 gallons of storage would be required for an EQ basin to balance the diurnal flows.

At the Town of Erie NWRF, the addition of an EQ basin would not substantially enhance the biological capacity of the IFAS secondary treatment system; an additional IFAS expansion is still required for this project. The secondary treatment basins currently have sufficient hydraulic retention to deal with diurnal fluctuations in flow. Additionally, the high capital costs associated with an equalization basin are not justified; HDR estimated that implementation and construction of an equalization basin would cost approximately $1.2 million. (See Appendix A for a detailed breakdown of this cost estimate.) For these reasons, an EQ basin is not recommended in the next plant expansion project.

7.5 Odor Control

The Town of Erie NWRF currently experiences odor issues in the headworks and dewatering buildings. As part of the plant expansion, long term and short term solutions to the high odor problems will be provided. This section evaluates, screens and selects the applicable foul air/odor control technology suitable for headworks and dewatering process odors. Each foul air/odor control technology alternative is described and the screening criteria presented. Screening criteria includes foul air/odor removal efficiency, capital cost, operating cost, and space requirements.

7.5.1 Odor Control Technologies

Biofilters

Biofilters absorb, adsorb, and oxidize odorous compounds using microorganisms in compost or mineral based media. The microorganisms metabolize and convert the odorous compounds to either non odorous or less odorous forms. Biofilters must be kept wet to support the microorganisms. For lower air flows less than 4,000 cubic feet per minute (cfm) packaged biofilters are available. Larger systems are typically either housed in a concrete system or in large earthen berm units at grade.

An advantage of biofilters is their ability to self-adapt to various odors and treatment of hydrogen sulfide up to 20 ppm. The microorganism population will shift according to the odorous compounds and compound concentrations that are present. Biofilter disadvantages include larger footprint, slower start up times, and the potential for sulfur buildup if treating sustained high hydrogen sulfide concentrations greater than 20 ppm. The energy requirements to push the ventilation air through the media are typically a little higher or about the same as activated carbon or dry media systems.

Two types of media can be used in biofilters: manufactured media or organic media. Manufactured media has been shown to last 10 to 15 years before requiring replacement. The manufacturers generally warrant the media for 10 years. Bark mulch media typically has to be replaced every 3 to 5 years, though is much less expensive than manufactured media. Manufactured media, such as Biorems Biosorbens media, has a longer life with retention time of 45 seconds empty bed retention time (EBRT) and a maximum bed depth of 5 FT. Bark mulch media is recommended to have no more than a 60 second EBRT. Figure 7-1 and Figure 7-2 display examples of inorganic and organic biofiltration media.

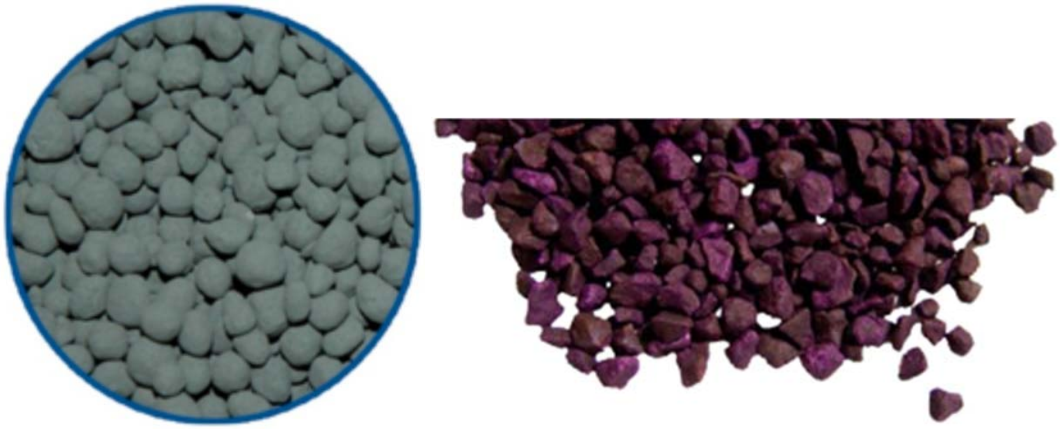


Figure 7-1. Examples of Inorganic Media for Biofiltration

Figure 7-2. Example of Organic Media for Biofiltration

Biofilters are meant to operate continuously to maintain biological activity. The biofilter is a living system that first must be acclimated and then sustained. It takes time for the media to be effective after a prolonged downtime.

Biotrickling Filter Scrubbers

Biotrickling filter scrubbers, are similar to chemical packed scrubbers but make use of microorganisms instead of a chemical solution. The microorganism solution is recirculated in the scrubber similar to the chemical solution in a chemical packed scrubber. Biotrickling filter scrubbers are essentially high rate biofilters without the organic media. As there is no organic media and the loading rate is high, a nutrient solution is typically required to supply the microorganisms certain nutrients. This can often be obtained from non-chlorinated wastewater plant effluent. Figure 7-3 displays an example of a biotrickling filter system.

A biotrickling filter, the same as biofilters, require non-sporadic operation since it is a living system. The biological media may die during the long durations of inoperation.

Additionally, micronutrients are required for this system and operation and maintenance are slightly higher than biofilters.

Figure 7-3. Example Biotrickling Filter System

Activated Carbon/Dry Media Scrubbers

Activated carbon scrubbers utilizes the surface of a carbon particle to provide a very large surface to volume ratio, which allows the particle to adsorb a large amount of foul air/odorous compound. Three types of activated carbon media can be used: conventional carbon (also sometimes known as coconut shell carbon), impregnated carbon, and catalytic carbon.

Activated carbon is very effective at removing odorous compounds and efficient up to the capacity of the carbon. However, once capacity has been reached, the removal efficiency drops sharply. As odor molecules accumulate on the internal surface area, the capacity of the adsorbent becomes exhausted and the media must be regenerated or replaced. Figure 7-4 displays an example image of a carbon scrubber.

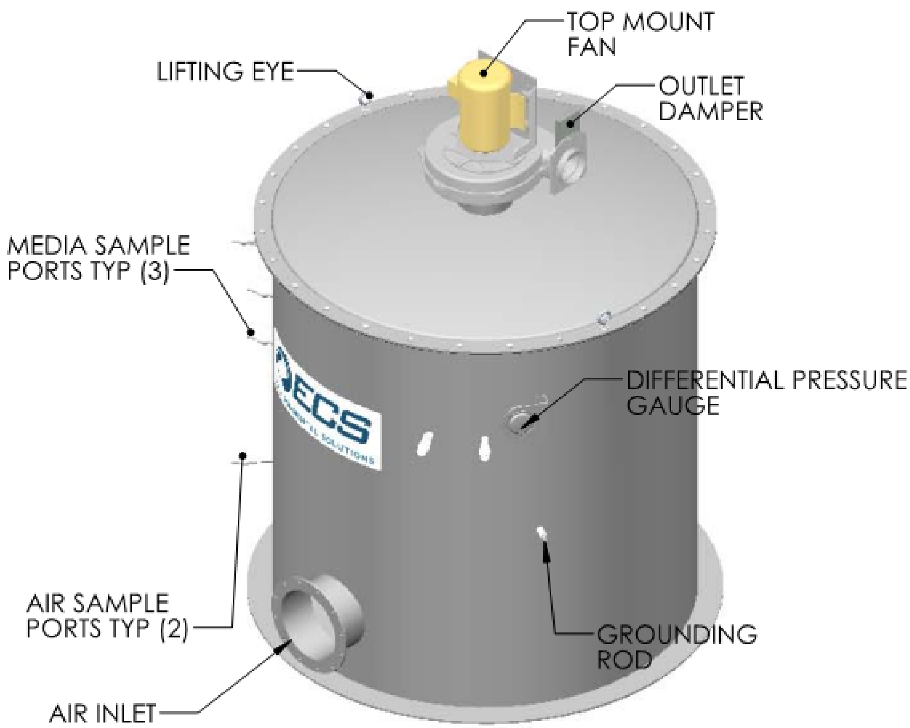


Figure 7-4. Example Activated Carbon Foul Air/Odor Control System

Hydrogen sulfide capacity per ASTM 6646-03 is a measure of the mass of hydrogen sulfide gas removed per unit volume of adsorbent media depicted as grams per cubic centimeter (g/cc). Table 7-1 shows activated carbon media products and their capacity to remove hydrogen sulfide. Although some products can have life expectancies up to 12 years, this is for hydrogen sulfide breakthrough only and does not account for the other odor constituents. In this application the reduced sulfur organic based odor species are likely of greater concern. It is recommended the carbon media be replaced every two to three years or as needed based on odor breakthrough.

Table 7-1. Treatment of H2S with Activated Carbon Products

Trade Name	Manufacturer	H2S Capacity, g/cc
Conventional activated carbon	Various	0.02
Add Skorb Sulfox	Jacoby	0.15
CC-IPH (CCG)	Continental Carbon	0.16
CPS 12	PureAir	0.16

The disadvantage of carbon and dry media filters is the requirement to replace the media more frequently than other types of scrubbers. The life expectancy of the media is dependent on the type of media, the amount of airflow through the scrubber, and the amount of constituents in the airstream. Carbon can get plugged slowly by grease or particulates (including insects). High moisture, especially in droplets, impacts the efficiency of some carbon blends, although high hydrogen sulfide capacity media requires humid air to be efficient. In situations with high potential for moisture and grease in the air stream, such as the dewatering and headworks buildings, a washable grease/mist filter upstream of the scrubber tank can be added. Also note that carbon scrubbers are not effective at removal of ammonia.

Chemical Packed Scrubbers

Chemical packed scrubbers are wet scrubbers which absorb odorous compounds into chemical solutions. The scrubber vessel is usually a large FRP enclosure filled with a plastic packing material. The packing media increases the surface area of the chemical solution to improve foul air removal efficiency. A recirculating chemical solution is continuously pumped and sprayed over the packing media in a counterflow direction with the ventilation air. Chemical metering pumps provide fresh chemical to the solution. By-products are removed along with some unused chemical through a blow down drain and fresh water make-up system. Chemical packed scrubbers typically use sodium hydroxide (caustic) and sodium hypochlorite (bleach) for hydrogen sulfide removal. Hydrogen sulfide removal efficiencies greater than 99 percent are typical for chemical packed scrubbers.

Chemical packed scrubbers can be maintenance intensive due to the number of mechanical components, sensors, and controllers. Equipment maintenance plus frequent checking of set points, adjusting feed and blow down rates can be significant. Also the media itself requires descaling via acid wash periodically. The required handling of chemicals adds a safety element to the system and needs to be accounted for within the Headworks and Dewatering Facilities. The chemical cost adds significantly to the overall economics. However, chemical scrubbers are effective at removal of ammonia. Additionally, a chemical scrubber system may be turned off when the facility is not being used. This can save energy used at the NWRF. Figure 7-5 displays an example chemical scrubber system.

Figure 7-5. Example Chemical Scrubber System

Headworks Building

The NWRF is located in close proximity to several residential neighborhoods and is conscious of odor affecting those communities. To prevent issues with the Town residents, a system can be applied to the exhaust system in the headworks building to reduce odors. Activated carbon filters can be installed at the exhaust fan louver intakes on several draw points in the building. The filters can be placed in easily accessible location for replacement of the filters. During the design process, the pressure drop through the filter and filter face velocity will be determined to verify filter size selection. Figure 7-6 and Figure 7-7 display the potential locations for the activated carbon air filters on the exhaust system, and an image of an example filter.

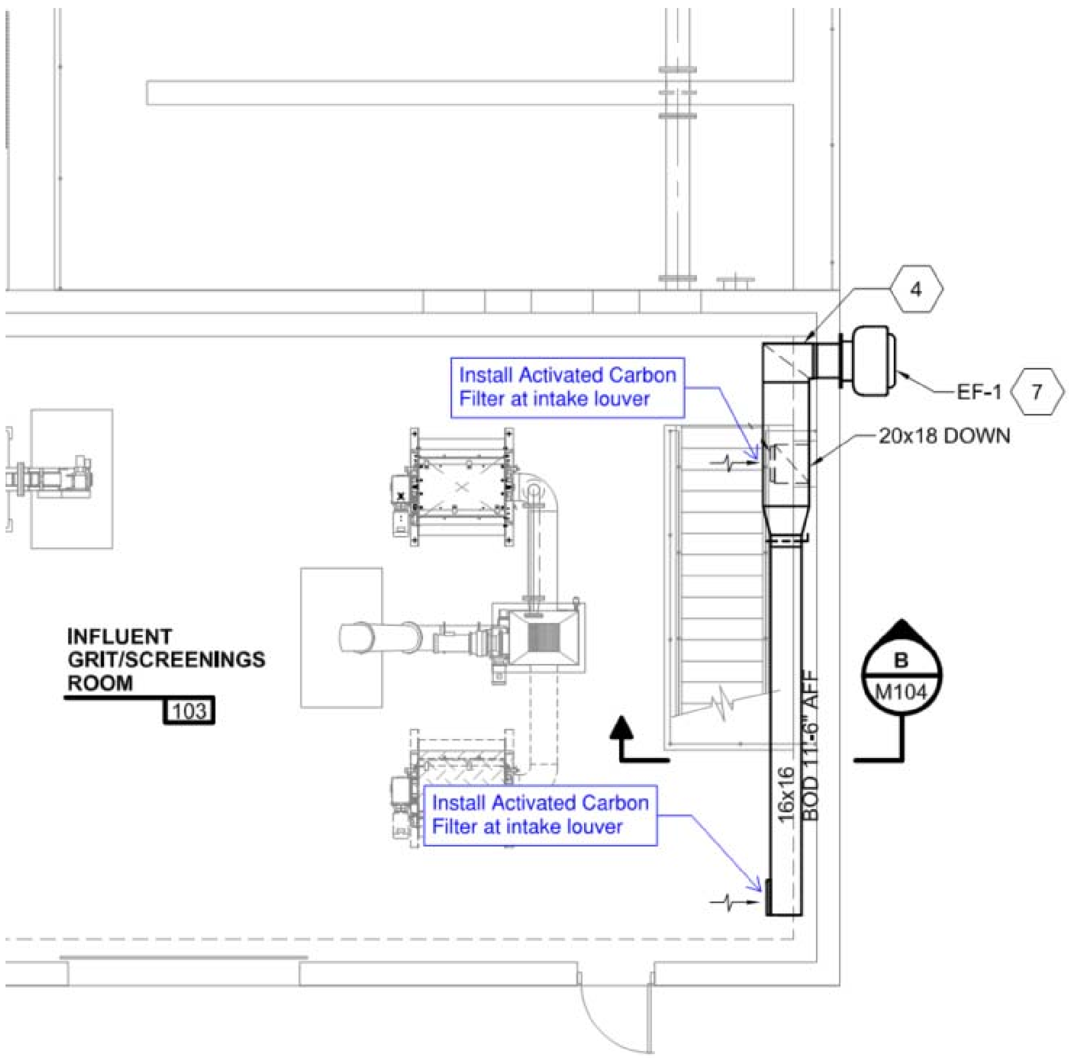


Figure 7-6 Location for Odor Control Activated Carbon Filters in Headworks Facility

Figure 7-7 Example Activated Carbon Intake Filter

Dewatering Building

The Dewatering Building at the NWRF is another building with potential for odors. The primary detectible odor in dewatering and solids digestion processes is typically hydrogen sulfide, whereas headworks facilities show high detectible levels of ammonia and hydrogen sulfide. For this reason, it is recommended for the dewatering and solids stabilization processes share a designated permanent odor control system, separate from the headwork odor control solution. The dewatering building odor control system can be combined with the new solids stabilization process, described in detail in Chapter 6 of this Master Plan. With the technologies presented in this section, a biofilter or biotower is an acceptable solution to the expected odor constituent concentrations in the system processes. Since solids treatment processes are anticipated to change in the next plant expansion, concentrations of odorous constituents cannot be measured for new processes at the NWRF. Odor concentrations at other facilities with similar solids treatment processes can be investigated during design for final selection of the appropriate odor control technology.

7.6 Influent Flow Measurement Improvements

The NWRF contains a magnetic flow meter (mag meter) to measure the influent flow, located downstream of the influent pumps. Because the pumps draw from two wet wells, it is difficult to analyze the flow data for an accurate diurnal curve. Additionally, some recycle flows are returned upstream of the influent pumps, resulting in inaccurate flows and loads readings from the existing mag meter. CDPHE has requested a more accurate flow measurement upstream of the headworks facility. The Town plans to provide and install a combined velocity and level sensor for accurate flow measurement in Manhole F67 of the 2012 NWRF Plant Expansion Project. The manhole inlet and outlet are inline and have limited elevation difference, providing a relatively accurate flow measurement. The elevation of the outlet invert of F67 is 4926.75, and the inlet invert elevation of F66 directly downstream is 4926.43

As part of the next plant expansion project, permanent electrical lines and conduit and SCADA programming will be incorporated.

7.7 Effluent Flow Measurement

Currently, the NWRF is able to accurately measure effluent directed to the reuse reservoir. However, there is no flow measurement method if effluent is discharged to the creek. The plant staff would like the ability to measure effluent discharged to both locations. For this reason, it is recommended that a parshall flume or a Palmer-Bowels flume and ultrasonic sensor be installed on the effluent pipeline to the creek, near the UV building. The recorded flow from either location will present the total effluent flow from the plant. Figure 7-8 displays a potential location for a parshall flume.

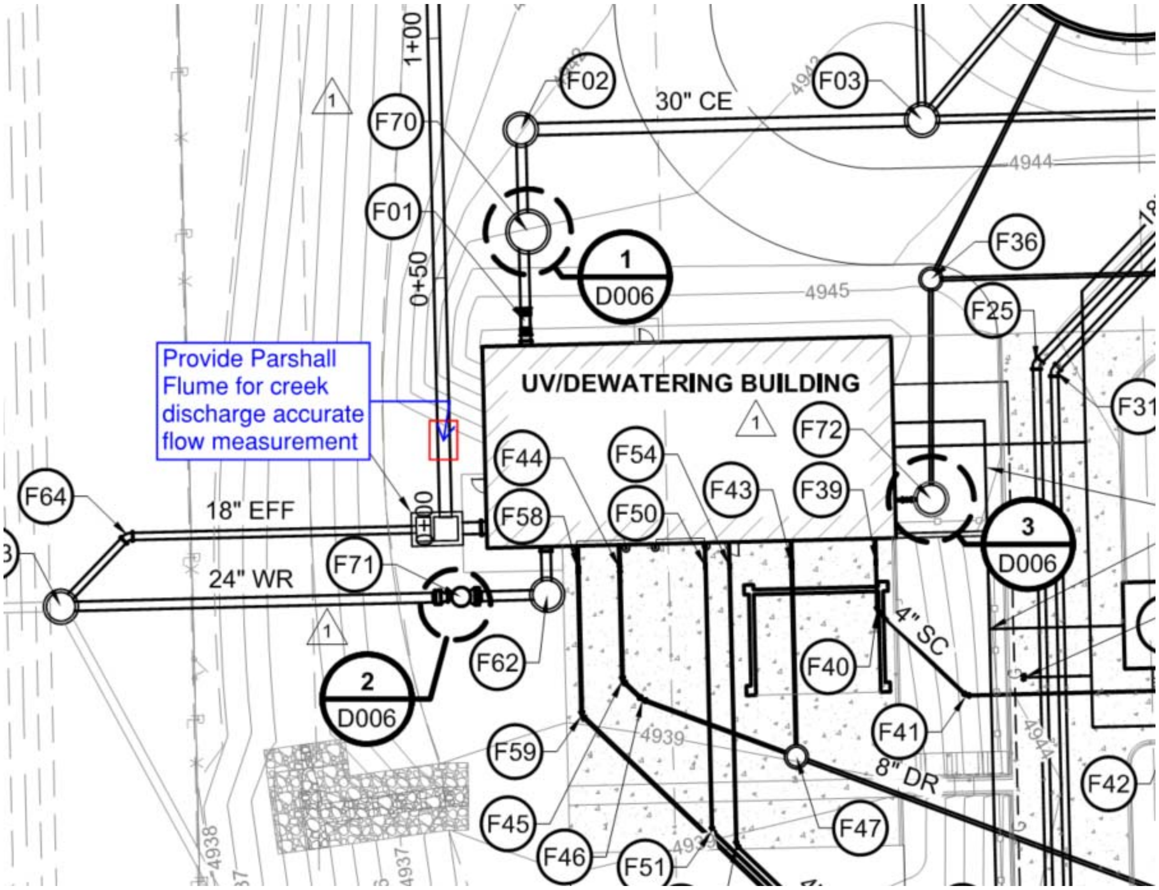


Figure 7-8 Effluent Parshall Flume Location

7.8 Wet Well Inspection and Coating

The headworks at the NWRF is equipped with two wet well basins after the bar screen and before the influent pumps. Because of the highly corrosive nature of influent wastewater, these wet wells are exposed to high levels of hydrogen sulfide (H_2S) which attack and corrode concrete. For this reason, it is recommended that the wet wells be inspected and coated with a high resistant H_2S SpectraShield® coating during the next plant expansion. Inspection and repair of one of the wet wells can occur while the other is kept in operation.

7.9 Non-potable Water System Improvements

The NWRF at the Town of Erie is equipped with a reuse pump station in the northwest corner of the facility, as well as non-potable water (NPW) pumps located in the basement level of the process building. The NPW pumps use effluent water for process water throughout the facility, whereas the reuse pump station draws from the reuse water pond and pumps to other locations, outside of the NWRF premises. Additional disinfection chemicals are injected in the reuse pump station.

The NPW Pumps in the basement of the process building supply process water to several treatment processes in the NWRF, such as the bar screens and grit classifier in the headworks, foam suppression sprayers in the IFAS aeration basins, lime wetting system for solids stabilization, and polymer wetting and sprayers for the FKC dewatering unit. Additionally, the NPW pumps provide water to all yard hydrants, hose bibs, and hoses on the facility premise. The NPW pumps are equipped with a flow meter and pressure gage at the discharge of the pumps; however, flow rates at each process point are unknown. Typically when all processes are operating, approximately 250 gpm are used. Approximately 30 gpm of that is used at the FKC screw dewatering unit. The pressure at the NPW pumps in the basement of the process building ranges between 40 and 54 psi. The yard hydrant at the secondary clarifiers is at an elevation approximately 23 ft higher than the NPW pumps. Consequentially, the maximum pressure without accounting for headloss and flow loss from flow to other processes is 44 psi. Additionally, the Town has explained that insufficient flow and pressure exit hoses connected to the NPW system. Typically, design for water pressure at water reclamation facilities range from 60 – 100 psi. Therefore, it is recommended that new NPW pumps be included as part of the next plant expansion which will accommodate existing and future process water demands. The increased NPW demands will be investigated in depth in the design phase of the project. It is recommended to include flow meters at process water points as part of the plant expansion.

In the near future, the Town of Erie will design and construct an additional reuse pipeline from the reuse pump station to a reuse storage tank offsite of the NWRF. The Town is interested in connecting an onsite irrigation system to the planned reuse pipeline. The feed line into this water storage tank is located near the bottom of the tank, which will provide hydraulic pressure for the irrigation system. Additionally, this tie-in location will allow for metering of irrigation system water use. Another way to provide irrigation system pressure would be to add a break tank and small pump exclusively for irrigation. However, given the low expected usage frequency of the irrigation system, the costs of this alternative may not be justified. Lastly, an irrigation line connection to the NPW pumps could be provided, instead of the reuse pipeline. The reuse pumps are much larger and would use more energy to operate the irrigation system. HDR recommends that irrigation system connection should be further evaluated during preliminary design of the next plant expansion.

7.10 Dewatering Polymer Improvements

The Town of Erie NWRF dewatering process is equipped with an emulsion polymer system. The polymer totes are located on the floor of the dewatering building without a designated area. To drain the polymer from the vessel, the totes are hoisted with a jib crane and polymer is transferred into a new tote. Figure 7-9 displays an image of the polymer transfer system. This form of polymer transfer is time consuming and precarious for the operational staff. Because of this, a designated polymer area and transfer system is recommended that can allow the operational staff to focus on other operational tasks. Figure 7-10 displays an image of an example polymer tote system design. The three totes sit on a sloped concrete pad to allow polymer to drain effectively from the tote. When one tote is drained, the valve can be closed and the second tote opened to allow a seamless transfer of polymer.

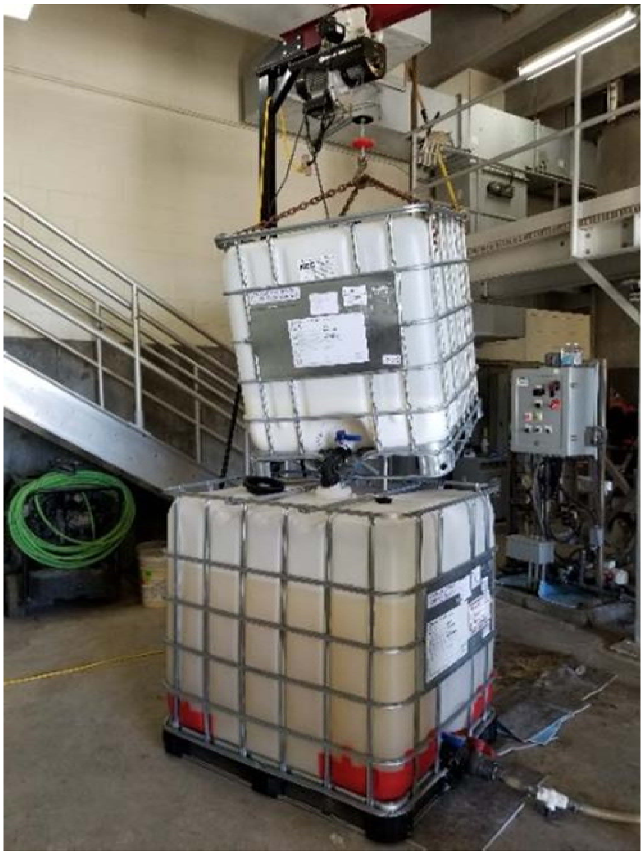


Figure 7-9 Existing Dewatering Polymer Transfer System

Figure 7-10 Example Polymer Design

7.11 Solar Panels

The Town of Erie is exploring the option of on-site solar powered renewable energy generation on building roof tops and unplanned vacant NWRF land. The geographical location of the Town receives a fair amount of sun radiation, approximately 5.3 kWh/m2 per day, making this part of the United States an attractive site for photovoltaic (PV) facilities.

Advantages of solar energy include:

- Can allow WPCF to become more energy self-sufficient.
- Financial incentives may be available.
- Visual impact can illustrate the use of green resources by WPCF.

Disadvantages of solar energy include:

- Requires a large area which cannot be used for other activities.
- May cost more than purchasing electricity.

The Town will not qualify for the Federal Investment Tax Credits (ITC) as municipal entities with no tax burden are not eligible. Additionally, United Power, the electrical power provider for the Town of Erie, does not provide rebates or incentives for a renewable energy option.

As the solar industry matures, installed system costs have been steadily declining, making solar PV systems more affordable. However with the absence of any financial incentives or rebates, HDR does not recommend the Town to install and own a PV generation facility since the simple payback period will be in excess of 15 years.

Alternatively, the Town may want to explore Power Purchase Agreements (PPA) with a private project developer who will install, operate and own a PV generation facility at the NWRF Facility. Through such an arrangement, the Town enters into a contracted, long-term, purchase of energy generated from the facility but without having to expend costs associated with construction, operation or maintenance of the solar power system. The PPA developer can take the Federal tax credits and accelerated depreciation, along with any available utility incentives on behalf of the customer, enhancing the financial viability of the project. A number of utilities in the area, such as Boulder, Greeley, Pueblo, and Rifle have installed PV systems through PPA. Greeley's obtained a PPA with Oak Leaf Energy Partners, Enfinity America Corp, and Intermountain Electric. This option should be explored via the Town's personnel. The feasibility of this alternative can only be ascertained once a developer is engaged, and rigorous financial planning is conducted.

7.12 Economic Evaluation

A summary of opinions of probable costs for the existing site improvements are presented in Table 7-2. The capital costs presented include the following key points:

- Dewatering Building odor control cost estimate is not included in this section since the recommendation is to combine the dewatering with solids stabilization odor control system and is included in the cost estimate for that facility.
- Solar Power project cost estimate is not provided as a partnership with a third party will vary on a case by case basis.
- Costs were developed based on five digit specification divisions (i.e. Division 1, 2, etc)

- 30 percent estimating contingency
- 10 percent contractor overhead and profit
- 20 percent engineering design/construction services
- 5 percent project contingency
- Provided as a “Total Anticipated Project Cost” which include all the above items

Table 7-2: Opinion of Probable Construction Cost

Town of Erie - NWRF Master Plan Existing Site Miscellaneous Improvements Summary		
Item	**Description**	**Budgeted Construction Cost**
1	Headworks Odor Control Improvements	$25,000
2	Influent Flow Measurement	$39,000
3	Effluent Parshall Flume	$41,000
4	Wet Well Inspection and Coating	$114,000
5	Non-potable Water System Improvements	$230,000
6	Dewatering Polymer Improvements	$8,000
	Total Existing Site Improvements Cost	***$457,000***

The anticipated project cost for each item is presented in Table 7-2. Appendix A contains the detailed cost estimates.

7.13 Recommendations

As part of the next plant expansion project, additional miscellaneous work will be performed to improve the working environment and treatment capability of several processes in the plant. The recommendations of the miscellaneous items described in this chapter include:

- Inspect and coat the influent wet wells in the headworks facility.
- Provide a maintenance building under a separate project.
- It is not recommended to provide an EQ basin.
- A permanent polymer transfer system will be included in the design of a dewatering facility.
- Separate odor control systems are recommended for the headworks and the solids treatment processes.

- Provide activated carbon filters on the exhaust fan system in the headworks.
- Provide a biological odor control system for the solids treatment processes.
- Include SCADA and electrical wiring in the construction project for the upstream influent flow measurement.
- Provide larger Non-potable water system pumps and flow meters at process points.
- Provide a parshall or Palmer-Bowles flume for effluent flow measurement.
- Solar power is not recommended for this project; however, the Town may connect with a third party and explore the option of a PPA.

Contents

8 Monetary and Non-Monetary Evaluation 8-1
- 8.1 Summary of Design Flows and Loads 8-1
- 8.2 Liquids Stream Monetary Evaluation 8-2
- 8.3 Solids Stream Monetary Evaluation 8-4
- 8.4 Existing Facility Site Improvements Monetary Evaluation 8-6
- 8.5 Summary of Recommended Project Costs 8-7
- 8.6 Non-Monetary Evaluation 8-8
- 8.7 Conclusion 8-11

Tables

Table 8-1. Summary of Recommended 10 and 20 Year Design Values 8-1
Table 8-2. Summary of Expansions/Improvements Needed at Erie NWRF 8-3
Table 8-3. Total Anticipated Project Costs of Liquids Stream Expansion Alternatives 8-3
Table 8-4. Breakdown of Costs for Primary Priorities in Liquids Stream Expansion 8-4
Table 8-5. Breakdown of Costs for Recommended Solids Stream Expansion 8-5
Table 8-6. NPV Analysis for Keep Existing and ATAD Alternatives 8-6
Table 8-7: Existing Facility Site Improvements Opinion of Probable Construction Cost 8-7
Table 8-8: Erie NWRF Expansion Project Opinion of Probable Construction Cost 8-8
Table 8-9: Liquids Stream Bid Alternates Opinion of Probable Construction Cost 8-8

Figures

Figure 8-1: Non-Economic Evaluation of Narrowed Alternatives 8-10

8 Monetary and Non-Monetary Evaluation

As mentioned in previous chapters, the Town of Erie's North Water Reclamation Facility (NWRF) is designed to treat 1.95 MGD of wastewater. Due to historical and anticipated rapid population growth in the area, the Town is planning an expansion of the NWRF to ensure the plant is adequately sized to handle the increased flows and loads.

This chapter summarizes the monetary and non-monetary evaluations for all recommended improvements and expansions to be performed in the NWRF's next expansion project. A summary of planning level cost estimates for the liquids stream, solids stream, and miscellaneous existing facility improvements is provided in this chapter, as well as an expected planning level cost for the entire project. All of the components of the recommended liquids and solids stream improvements are provided in Chapters 5 and 6 of this Master Plan, respectively. Lastly, the non-monetary evaluation for the long-term biosolids stabilization alternatives is provided in this chapter as well.

8.1 Summary of Design Flows and Loads

Chapter 3 previously provided a description of the methods used to obtain the projected flows and loads to the Erie NWRF. In order to provide cost estimates for each recommended improvement, HDR sized equipment and expansion measures based on a set of design flows and loads. In general, the expansion was sized for a 10 year planning window, with space preserved to accommodate for 2038 flows and loads conditions. A summary of the influent flows and loads, as well as the solids flow values for the ten and twenty year design frames are provided below in Table 8-1.

Table 8-1. Summary of Recommended 10 and 20 Year Design Values

Parameter	2028	2038
Projected Population	49,226	80,184
Avg. Day Influent Flow (MGD)	2.80	4.56
Max. Month Influent Flow (MGD)[a]	3.03	4.93
Avg. Day Influent BOD Loading (lb/day)	6,997	11,398
Max Month Influent BOD Loading (lb/day)	9,376	15,273
Avg. Day Influent TSS Loading (lb/day)	7,193	11,717

Table 8-1. Summary of Recommended 10 and 20 Year Design Values

Parameter	2028	2038
Max Month Influent TSS Loading (lb/day)	9,709	15,815
Avg. Day Influent Ammonia Loading (lb/day)	840	1,368
Max Month Influent Ammonia Loading (lb/day)	1,114	1,814
Avg. Day Influent TP Loading (lb/day)	443	722
Max Month Influent TP Loading (lb/day)	618	1,007
Max Month RAS Flow (MGD)[b]	3.03	4.93
Max Month RAS Flow (lb/day)[b]	346,202	563,291
Max Month WAS Flow (gpd)[b]	102,711	160,650
Max Month WAS Flow (lb/day)[b]	11,700	18,300
Max Month Dewatered Solids Flow (lb/day)[c]	14,040	21,960

[a] Based on 61.5 gpcd wastewater generation rate per capita.
[b] Based on projected solids flow rates provided by Kruger. Assumes secondary treatment expansion.
[c] Assumes no change in existing solids treatment process. Based on a 1:5 ratio of lime to WAS solids use. See chapter 6.

8.2 Liquids Stream Monetary Evaluation

The liquids stream improvements are described in Chapter 5. The needs identified for the liquids stream process were categorized into three tiers of priority. A summary of the recommended liquids stream expansion and improvement measures sorted by priority are in Table 8-2 below.

Table 8-2. Summary of Expansions/Improvements Needed at Erie NWRF

Primary Priority	Secondary Priority	Tertiary Priority
• 2nd Grit System • 3rd IFAS Basin • Addition of Anoxic and Re-aeration Zones on Each Basin • RAS/IR Separation • Addition of new IR in-basin pumps • Grit Pump • 4th Influent Pump	• Blower replacement • Second Grit Snail (Bid Alternate Options)	• Headworks Screen • 2nd Disc Filter (Bid Alternate Options)

At the very least, the items listed as a "primary priority" should be included in the next expansion project at the NWRF. The items listed as secondary or tertiary priorities should be included as bid alternates for the next expansion project, and included only if budget allows.

The monetary evaluation for the liquids stream improvements included four liquids stream expansion alternatives: IFAS expansion with primary priorities, IFAS expansion with primary and secondary priorities, IFAS expansion with primary, secondary, and tertiary priorities included, and the second disc filter located indoors, and lastly IFAS expansion with primary, secondary, and tertiary priorities included, and the disc filter located outdoors. Table 8-3 below provides a summary of the cost estimates for each of these liquids stream expansion alternatives.

Table 8-3. Total Anticipated Project Costs of Liquids Stream Expansion Alternatives

Alternative	Total Anticipated Project Cost (TAPC)
IFAS Expansion with Primary Priorities	$8,974,000
IFAS Expansion with Secondary Priorities	$10,086,000
IFAS Expansion with Tertiary Priorities (Expand Dewatering/UV Building)	$11,858,000
IFAS Expansion with Tertiary Priorities (No expansion of Dewatering/UV Building)	$11,702,000

As mentioned previously, the next expansion project at the NWRF should include at least the primary priorities. A more detailed breakdown of the primary priorities for the liquids stream improvements are provided below in Table 8-4. Detailed cost estimates for all alternatives are provided in Appendix A.

Table 8-4. Breakdown of Costs for Primary Priorities in Liquids Stream Expansion

Item	Cost
General Conditions Subtotal	$453,000
Sitework Subtotal	$254,000
Concrete Subtotal	$1,459,000
Thermal and Moisture Protection Subtotal	$15,000
Specialties Subtotal	$35,000
Equipment Subtotal	$1,924,000
Mechanical Subtotal	$280,000
Electrical and Instrumentation Subtotal	$560,000
TOTAL DIRECT COSTS SUBTOTAL	**$4,980,000**
TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL (Includes 30% Contingency and 10% for General Contractor Overhead, Profit, and Risk)	**$7,121,000**
TOTAL ANTICIPATED PROJECT COST (TAPC) (Includes Engineering Design, Construction Services, Permits, and 5% Town Project Contingency)	**$8,974,000**

The overall project costs included in Section 8.5 assume that the project will include only primary priorities for liquids stream expansions and improvements, and that the secondary and tertiary priorities will be included as bid alternates.

8.3 Solids Stream Monetary Evaluation

The solids stream improvements are described in Chapter 6. For the existing solids stream capacity expansion, the following recommendations were provided for inclusion in the next expansion project at the NWRF:

- New solids dewatering pump
- Improved/expanded WAS thickening process
- Lean-to structure for solids storage
- Distribution screw for dewatered solids
- Solids storage tank inspection and lining

Additionally, for the long-term biosolids stabilization process at the NWRF, the following recommendations were provided:

- Implement ATAD as new biosolids stabilization process for Class A biosolids at Erie NWRF. Install a new biosolids stabilization facility sized for 2028 conditions, with two ThermAer tanks, one SNDR tank, a biofilter, building space for ancillary equipment, and leave room for expansion to 2038 conditions.

- Demolish FKC dewatering screw press and install a new dewatering system with redundant units in the Dewatering Building. The dewatering technology selection should be further evaluated during the next expansion project predesign.
- Install new polymer system with mixing/aging tank for emulsion polymer. Consider a dry polymer system for use during the winter.

Table 8-5 below provides a summary of the cost estimates for the recommended solids stream improvements and expansions.

Table 8-5. Breakdown of Costs for Recommended Solids Stream Expansion

Item	Cost
General Conditions Subtotal	$767,000
Sitework Subtotal	$153,000
Concrete Subtotal	$1,428,000
Masonry Subtotal	$239,000
Metals Subtotal	$10,000
Thermal and Moisture Protection Subtotal	$135,000
Doors and Windows Subtotal	$32,000
Finishes Subtotal	$30,000
Equipment Subtotal	$4,527,000
Special Construction Subtotal	$125,000
Mechanical Subtotal	$183,300
Electrical and Instrumentation Subtotal	$806,000
TOTAL DIRECT COSTS SUBTOTAL	**$8,435,000**
TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL (Includes 30% Contingency and 10% for General Contractor Overhead, Profit, and Risk)	**$12,063,000**
TOTAL ANTICIPATED PROJECT COST (TAPC) (Includes Engineering Design, Construction Services, Permits, and 5% Town Project Contingency)	**$15,202,000**

While performing monetary evaluations for all solids stabilization alternatives, in order to further evaluate the relative cost savings of the Keep Existing alternative, the 10 and 20 year net present value (NPV) calculations were performed for the Keep Existing and ATAD alternatives. The results of this analysis were provided previously in Chapter 6, and are shown below as well.

Table 8-6. NPV Analysis for Keep Existing and ATAD Alternatives

Alternative	Total Anticipated Project Cost (TAPC)
ATAD	$15,202,000
Keep Existing	$7,814,000
Alternative	**10 Year NPV**
ATAD	$23,947,000
Keep Existing	$23,659,000
Alternative	**20 Year NPV**
ATAD	$45,334,000
Keep Existing	$65,191,000

This analysis showed that although the initial capital costs of the ATAD system are significantly higher than the Keep Existing option, the total net present value costs begin converging over time, due to the continued use of lime, and the higher biosolids hauling costs associated with keeping the existing system. Additionally, after 10 years of keeping the existing system, substantial improvements, including two new FKC Class A systems with all ancillary equipment, further building expansion, and improvements to the solids storage tanks would be required to meet 2038 conditions. The detailed cost estimates for all solids improvement alternatives are provided in Appendix A.

8.4 Existing Facility Site Improvements Monetary Evaluation

Chapter 7 summarizes a number of existing facility improvements that are recommended for inclusion in the next expansion project at the NWRF. These include:

- Inspect and coat the influent wet wells in the headworks facility
- Provide permanent polymer transfer system in dewatering facility
- Provide separate odor control systems for the headworks and the solids treatment processes
- Provide activated carbon filters on the exhaust fan system in the headworks
- Provide a biological odor control system for the solids treatment processes
- Include SCADA and electrical wiring in the construction project for the upstream influent flow measurement
- Provide larger non-potable water system pumps and flow meters at process points
- Provide a parshall or Palmer-Bowles flume for effluent flow measurement

A summary of opinions of probable costs for the existing site improvements are presented in Table 8-7. Dewatering Building odor control cost estimate is not included in this section since the recommendation is to combine the dewatering with solids stabilization odor control system and is included in the solids stream improvements cost estimate. Similar to cost estimates provided for liquids and solids stream improvements, the cost estimates provided in the table below use the following assumptions:

- Costs were developed based on five digit specification divisions (i.e. Division 1, 2, etc…)
- 30 percent estimating contingency
- 10 percent contractor overhead and profit
- 20 percent engineering design/construction services
- 5 percent project contingency
- Provided as a "Total Anticipated Project Cost" which include all the above items

See Appendix A for detailed cost estimates for the existing facility site improvements.

Table 8-7: Existing Facility Site Improvements Opinion of Probable Construction Cost

Town of Erie - NWRF Master Plan Existing Site Miscellaneous Improvements Summary	
Description	**Budgeted Construction Cost**
Headworks Odor Control Improvements	$34,000
Influent Flow Measurement	$44,000
Effluent Parshall Flume	$37,000
Wet Well Inspection and Coating	$61,000
Non-potable Water System Improvements	$158,000
Dewatering Polymer Improvements	$21,000
TOTAL DIRECT COSTS SUBTOTAL	**$355,000**
TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL (Includes 30% Contingency and 10% for General Contractor Overhead, Profit, and Risk)	**$507,000**
TOTAL ANTICIPATED PROJECT COST (TAPC) (Includes Engineering Design, Construction Services, Permits, and 5% Town Project Contingency)	**$650,000**

8.5 Summary of Recommended Project Costs

In order to provide a planning level cost estimate for the entire expansion project at the NWRF, the costs for the solids stream, liquids stream, and existing facility improvements were all added, and are presented below in Table 8-8.

Table 8-8: Erie NWRF Expansion Project Opinion of Probable Construction Cost	
Item	**Cost**
IFAS Expansion with Primary Priorities	$8,974,000
Solids Stream Improvements (Existing Capacity Expansion and ATAD)	$15,202,000
Existing Facility Site Improvements	$650,000
TOTAL ESTIMATED PROJECT COST	**$24,826,000**

This total project cost estimate assumes that only the primary priorities in the liquids stream expansion are provided in the base project scope. However, the secondary and tertiary priorities may be added as bid alternates for inclusion in the next NWRF expansion project as budget allows. Table 8-9 below shows the potential added costs if the secondary and tertiary priority improvements are added to the liquids stream expansion portion of this project.

Table 8-9: Liquids Stream Bid Alternates Opinion of Probable Construction Cost	
Item	**Cost**
Secondary Priorities (blower replacement and second grit dewaterer/classifier)	$1,112,000
Secondary and Tertiary Priorities (secondary priorities, headworks mechanical screen, and second disc filter located in expanded building)	$2,884,000
Secondary and Tertiary Priorities (secondary priorities, headworks mechanical screen, and second disc filter located outdoors)	$2,728,000

The detailed cost estimates for both the bid alternate options, as well as the line items in Table 8-8 above, are provided in Appendix A.

8.6 Non-Monetary Evaluation

The non-economic evaluation plays a key role in the selection process. It captures the criteria that are not associated with cost, but that are important for ensuring that the new biosolids stabilization alternative is implemented as seamlessly as possible at the NWRF. For the non-economic evaluation of the solids stream alternatives, HDR compared the solids stream alternatives based on the criteria listed below. Each criterion was assigned a rating from 1 to 5, with 5 being the highest (best) rating attainable. The ratings were then added and divided by the total possible score to define a weighted score for each alternative. The ratings presented in Chapter 6 and again below were developed by HDR and presented to the Town of Erie staff to confirm agreement with the results.

The non-economic evaluation for the solids stream alternatives was based on scoring of each criterion, applying a weighting factor, and calculating a “total benefit” for each alternative. The determination of weighting factors are explained in Chapter 6. The “total benefit” values, coupled with the economic analysis, provide an overview of the relative costs and benefits for each alternative. Following is a description of the non-economic criteria, specific to solids stream treatment system. These criteria descriptions were also presented in Chapter 6. The detailed scoring for the non-economic evaluation shown below is provided in Appendix B.

Operator Attention

An alternative is rated high for operator attention if the technology operates efficiently on set-points that do not need frequent tuning. The staff at NWRF prefers equipment that is easy to operate with minimal control complexity. Automated systems are preferred while systems that require operators to be present to adjust settings are scored lower.

Operator Familiarity

Equipment the operators are familiar with receives a higher score. Changing to a new type of equipment may be beneficial for other categories, but would take additional operator attention while staff becomes familiar with the equipment.

Maintenance Requirements/Complexity

Ease of maintenance and timeline of repairs are important to NWRF staff. Equipment with minimal regular maintenance requirements is preferred. An alternative with an equipment layout that provides good equipment access receives a higher score. Equipment that requires excessive downtime or parts to be sent out to be machined receives a lower score.

Flexibility to Meet Future Flows and Loads Needs

An alternative is rated higher if it has flexibility to meet the future flows and loads requirements. A process that is easily expanded, where equipment can easily be added to increase capacity of that process.

Footprint

Due to potential space constraints of the site to meet distant future flow/load requirements, an alternative was rated higher if it was more efficient with footprint.

Implementability

Implementability is how easily the alternative can be constructed and incorporated into the existing systems. Technologies that require more complicated retrofits or more time for permitting and approval received lower scores than those that can be installed using the existing layout and equipment at the NWRF.

Redundancy

An alternative that provides greater overall redundancy and ability to take one train offline for maintenance was rated higher.

Robustness/Long-Term Sustainability

The robustness criterion evaluates the proven lifespan of equipment. Technologies that have been used for decades and are proven to meet requirements similar to NWRF's receive a higher score. Technologies that are emerging in the domestic market or are reported to be more troublesome than others were scored lower.

Safety

Alternatives that introduce greater health risks during operation and maintenance to the NWRF staff received lower scores than those that have lower risk of accidents.

The weighted benefit scores for the solids stream alternatives are shown in **Error! Reference source not found.**.

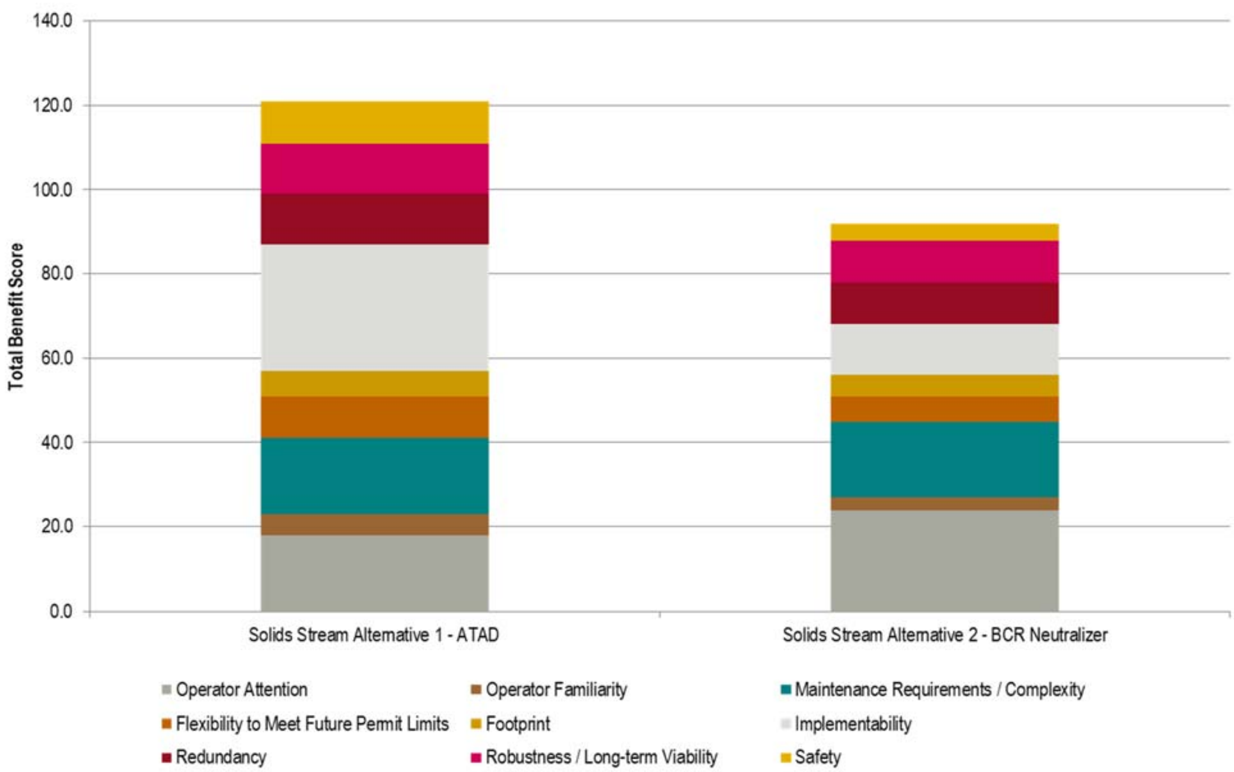


Figure 8-1: Non-Economic Evaluation of Narrowed Alternatives

As shown, the ATAD alternative received the highest non-economic score, followed by BCR's Neutralizer for Class A solids option. Although the BCR technology had higher scores for operator attention, ATAD received the highest scores in implementability, redundancy, safety, and flexibility to meet future permit limits. Since ATAD is already established as a PFRP accepted by the EPA, the risk of the NWRF encountering issues producing Class A biosolids in the future due to changing regulations is lower than for BCR's Neutralizer. This also allows for better implementability of ATAD, since permit approval is more straightforward than for the other alternatives. It also can be constructed as a standalone system, minimizing impacts to ongoing operations as it is constructed.

As mentioned already in Chapter 5, a non-economic evaluation was not performed for the liquids stream expansion alternatives. The liquids stream expansion alternatives are generally all variations of the same process and technologies. This makes a non-economic evaluation less applicable and of limited value for the liquids stream improvements, because the alternatives differ only by the extent of expansions that the Town's budget will allow for. Additionally, the liquids stream evaluation did not assess various technologies for a new process; rather, it categorized improvements and expansions that are necessary within the next twenty years into three tiers of priority. This categorization ensured that redundancy was prioritized for the recommended expansions and improvements at the NWRF. By prioritizing redundancy and plant robustness, this evaluation of liquids stream expansion alternatives also captured risk, safety, ease of operations, and flexibility as well, which are all often criteria used in a non-economic evaluation. For the remaining criteria, such as operator familiarity, operator attention, implementability, and robustness, each alternative would be scored similarly, since they are each variations of the same process and technologies.

8.7 Conclusion

Based on the monetary and non-monetary evaluations for the recommended improvements provided above, HDR anticipates that the planning level project costs for the next expansion project at the Erie NWRF will be approximately $24.6 million. This work includes the design and construction of the plant's IFAS process expansion, additional liquids stream equipment capacity expansions and improvements, a new ATAD facility, a new dewatering facility, and several miscellaneous existing facility site improvements. Up to $2.9 million in bid alternates may be added to this project for additional liquids stream equipment expansions. Additionally, based on the non-economic evaluation performed for the long-term biosolids stabilization alternatives discussed in Chapter 6, HDR and the Town of Erie confirmed that ATAD was the most viable alternative for the NWRF.

Contents

9 System Recommendations and Capital Improvements Plan ... 9-1
9.1 Introduction ... 9-1
9.2 Project Specific Permitting ... 9-1
9.3 Wastewater Infrastructure Improvements Program ... 9-2
9.3.1 Plant Expansion Project Phase 1 ... 9-2
9.3.2 Miscellaneous Improvements Project (MIP) ... 9-5
9.3.3 Liquids Improvements Project Phase 1 (LIP1) ... 9-6
9.3.4 Liquids Improvements Project Phase 2 (LIP2) ... 9-7
9.3.5 Expansion Project Phase 2 (EP2) ... 9-8
9.3.6 Master Plan Updates ... 9-9
9.4 High-Level Project Cost Estimates ... 9-9
9.5 Proposed Wastewater Infrastructure Improvements CIP ... 9-9

Tables

Table 9-1. CDPHE Regulation 22 Requirements ... 9-2
Table 9-2. High-Level Budgetary Estimates for Anticipated Projects ... 9-9

Figures

Figure 9-1. Triggers and Improvements Projects ... 9-11
Figure 9-2. Projects Site Implementation ... 9-13

This page is intentionally left blank.

9 System Recommendations and Capital Improvements Plan

9.1 Introduction

The Town of Erie has limited resources to invest in wastewater infrastructure, making prioritization of capital improvement projects a necessity. Multiple criteria govern the prioritization of capital improvement projects. The following list highlights the criteria that dictate capital improvements priorities for wastewater treatment and solids handling:

- Renewal and replacement
- Impaired operations and maintenance
- Permit requirements
- Surface water protection
- Protection of public health
- Treatment system reliability and operations requirements
- Coordination and compatibility with other capital programs
- Regulatory compliance
- Growth

This chapter presents the recommended wastewater treatment improvements for the NWRF described in the previous chapters. The recommended improvements are organized into logical projects according to projected growth, equipment capacity, schedule, type of work, location, and cost. Altogether, the projects recommended as part of the CIP will increase operational efficiencies, improve operations and maintenance, replace fixed assets in a timely manner to maintain the high level of operational reliability, and provide value to rate payers in a strategic implementation approach, as well as providing for growth and new discharge regulations.

While the CIP recommends significant improvements over the next 20 years, it also includes a programmatic approach to optimize the use of existing facilities to meet near-term regulatory and capacity requirements, and to provide adequate time to study and pilot test viable alternatives to ultimately reduce the extent of the recommended capital and operational expenditures in the long term.

9.2 Project Specific Permitting

The CIP will also be a resource for future Site Location Approval Applications and preliminary engineering reports submitted to the Colorado Department of Public Health and Environment (CDPHE). (The Colorado Discharge Permit System [CDPS] permit and the Colorado Water Quality Control Act require initiation of engineering and financial planning when throughput has reached 80 percent of rated design capacity.)

Prior to commencing any of the projects recommended as part of this Plan, Erie should comply with CDPHE Water Quality Control Division (WQCD) site location and design approval regulations, policies and guidance for domestic wastewater treatment works.

provides a summary of the CDPHE Regulation 22 Site Application requirements.

Table 9-1. CDPHE Regulation 22 Requirements	
Submittal	**Notes**
Site Location Approval CDPHE - Regulation 22	Required for construction of new domestic wastewater treatment works, increasing design capacity of wastewater treatment works, certification procedures for eligible interceptor sewers, construction of inceptor sewers or lift stations, amendments to existing Site Location Approval, and In-Kind Replacement.
Design Approval CDPHE - Regulation 22	Design Approval occurs typically after receiving Site Location Approval and before construction activities commence. There are two pathways for receiving Design Approval and both require a Process or Basis of Design Report submittal and final design documentation.

The WQCD regulation requires that no person shall commence construction of any domestic wastewater treatment works, or the enlargement of the capacity of an existing domestic wastewater treatment works (or process component thereof), unless the site location and the design for the construction or expansion have been approved by the WQCD. Adequate time for attaining this approval has been factored into the recommended project durations.

9.3 Wastewater Infrastructure Improvements Program

The goals for the Wastewater Infrastructure Improvements Program includes improving liquids and solids treatment processes, while adapting to changes associated with aging infrastructure, increased influent flows and loads projections, and long-term regulatory conditions. This CIP has organized the improvements into five projects spread over the next 20+ years:

- Plant Expansion Project Phase 1 (EP1)
- Miscellaneous Improvements Project (MIP)
- Liquids Improvements Project Phase 1 (LIP1)
- Liquids Improvements Project Phase 2 (LIP2)
- Expansion Project Phase 2 (EP2)

A description of each of the Wastewater Infrastructure Improvements Program Projects is included in the following sections, along with definitions of the recommended projects and studies (if applicable) that make up each project.

9.3.1 Plant Expansion Project Phase 1

The goal of the Plant Expansion Project Phase 1 (EP1) is to provide solutions for the NWRF’s liquids and solids streams capacity limitations, and several performance issues. As discussed in previous chapters, the Town’s recent growth has caused the NWRF to become restricted in its ability to process and treat influent flows and loads. Additionally, the existing solids treatment process has several issues including operational and maintenance challenges, as well as its unreliability for producing Class A biosolids. The tasks included in this project’s scope are intended to increase the plant’s hydraulic and treatment capacity to a maximum month influent flow of 3.03 MGD, and provide a more sustainable and improved solids treatment process that can reliably produce Class A biosolids, and eliminate the existing issues associated with the NWRF's current solids treatment process. This project will provide the following key components:

- Third IFAS Basin –
  - A third IFAS basin will be constructed to provide additional secondary treatment capacity. This basin will contain an anaerobic zone, followed by an anoxic zone, two Hybas (aerated) zones, a swing zone, post-anoxic zone, and a reaeration zone.
- Addition of Anoxic and Re-aeration Zones on Each IFAS Basin –
  - In order to make all three IFAS trains identical treatment-wise, a swing zone, post-anoxic zone, and reaeration zone will be added to the north end of the NWRF's existing two IFAS trains. The third IFAS train will be constructed first, and once that work is complete, all flow will be sent to the third IFAS train while the existing two IFAS trains are under construction.
- RAS/IR Pumping Separating –
  - The NWRF's existing RAS and IR pumps are limited in their capacity to provide the necessary RAS/IR flows for the expanded IFAS process. These existing pumps will be converted to RAS/WAS pumping only, and new in-basin propeller-style pumps will be added to the three IFAS trains for IR pumping.
- Second Grit System –
  - Since the NWRF's existing grit handling chamber is positioned in between IFAS Trains 1 and 2, a second grit chamber must be constructed to service the third IFAS train. This grit chamber will accept influent flow, and pump grit with a second new grit pump to the plant's existing grit dewaterer and classifier. A second grit dewaterer/classifier should be added to this project's scope if budget allows.
- Fourth Influent Pump –
  - In order to split flow to the three IFAS trains and maintain the required influent pumping redundancy, a fourth influent pump must be installed at the NWRF. Two of the influent pumps will direct flow to the existing two IFAS trains, and the other two will direct flow to the other two IFAS basins.
- New Thickening Feed Pump –
  - A second thickening feed pump will be added to provide the necessary capacity and redundancy requirements for the WAS pumping equipment.
- Lean-to Structure for Solids Storage –
  - An enclosed lean-to structure will be constructed for the storage of dried biosolids. Currently, dried biosolids are stored on the ground beneath an open lean-to structure. Installing a roll-off dumpster or dump truck, and enclosing the lean-to will help to contain any potential odors and also improve the biosolids haul-off procedure. Additionally, a distribution screw will be constructed on the

end of the existing discharge screw to provide equal distribution of material over the length of the roll-off dumpster or truck.

- Solids Storage Tank/Influent Wet Well Inspection and Lining –
  - This task will help to protect the NWRF's existing infrastructure. Plant staff have noted that some of the tank interior walls are undergoing degradation due to continued exposure to hydrogen sulfide. The solids storage tanks and influent wet wells will be inspected, blasted, and coated as necessary to protect these tanks from further deterioration.
- Addition of ATAD Facility –
  - A new ATAD biosolids stabilization facility will be constructed at the NWRF and sized for 2028 solids loading conditions, to replace the plant's existing lime/pasteurization biosolids process. The facility will produce Class A biosolids, and include two ThermAer tanks, one SNDR tank, a biofilter, building space for ancillary equipment, and leave room for expansion to 2038 conditions.
- New Dewatering Units –
  - The plant's existing dewatering screw press is severely limited in its capacity to process current and future biosolids loads. The screw press will be demolished and replaced with two new dewatering units, which will be installed in the Dewatering Building. Each unit will be capable of processing anticipated solids flows for 2038 maximum month conditions, so that complete process redundancy is provided. The exact dewatering technology will be selected during design.
- New Thickening Units –
  - In addition to the dewatering system improvements, the solids thickening system will undergo the necessary expansions and improvements to accommodate the new ATAD facility. The thickening units will be installed in the Dewatering Building if space allows, and the exact technology and potential reuse of the plant's existing rotary screen thickener will be further deliberated during design. The polymer system for both the thickening and dewatering processes will also be expanded and optimized as necessary.
- Odor Control –
  - New odor control will be provided for the ATAD facility and for the Headworks and solids processing facilities. The Headworks facility will have a separate odor control technology from the Dewatering Building and ATAD facility, which will utilize a biofilter.
- NPW System Improvements –
  - The plant's NPW pumps will be upsized to provide the necessary capacity and pressure for various non-potable water uses throughout the plant. The plant's irrigation system will also be tied into the reuse pump station's transmission line to a water storage tank.
- Effluent Flow Measurement –

- A flow monitoring technology will be added on the effluent line to Boulder Creek. The exact technology and location for effluent flow measurement will be determined during design.

Project Triggers

This project is required in the near term to address the following triggers:

- CDPHE Requirements [Reg No. 61.8(7)]
    - Flows reaching 95% of plant's approved capacity triggers the requirement to start expansion construction
    - 95% of Plant Capacity = 1.85 MGD (The plant reaches maximum month flow of 1.85 MGD between 2019 and 2020, according to flow projections.)
- Nitrogen Loads into Facility
    - Higher nitrogen loading into facility than original design was intended for. Increased secondary treatment capacity allows the NWRF to meet Regulation 85 requirements.
- Current Solids Stabilization and Handling
    - Existing biosolids treatment process is not achieving Class A as designed.

Project Schedule

This project is scheduled to begin design in 2019 with construction finishing by the end of 2022, and facility start-up occurring by the beginning of 2023.

Project Constraints

The following constraints may affect the timing and scope of this project and should be re-evaluated prior to initiating:

- Adequate budget to include all the project components.

9.3.2 Miscellaneous Improvements Project (MIP)

The goal of the Miscellaneous Improvements Project (MIP) is to construct the remaining improvements not included in the Plant Expansion Phase 1 Project due to cost constraints and scheduling. This project will provide the following key improvements:

- Blower Improvements/Capacity Expansion –
    - Existing aeration blowers have an approximate total capacity of 10,877 scfm, a firm capacity of 7380 scfm, and the required 2028 firm capacity for IFAS is 9500 scfm. Additionally, existing blowers do not perform reliably, and some units may require repair or complete replacement. EP1 project may address some improvements for performance and functionality of existing blowers, but the MIP will provide necessary blower capacity expansions and improvements required to meet 2028 firm capacity requirements.
- New Maintenance Building –

- As noted in Chapter 7, the Town will be implementing a packaged, cost-effective solution for a new maintenance building at the NWRF. This building will provide necessary footprint for equipment and tool storage, and help to ease existing space constraints for miscellaneous storage.

Project Triggers

This project is required to provide the necessary blower aeration capacity for the expanded IFAS process that is being constructed as part of the EP1 project, and ensures that sufficient and reliable aeration is provided for secondary treatment at the NWRF. Additionally, the maintenance building was initially an item intended to be included in the EP1 project, but that has been eliminated from the scope of that project. The miscellaneous improvements project will capture the construction of the maintenance building as a packaged solution.

Project Schedule

This project is recommended to begin design in 2024 with construction finishing by the end of 2025.

Project Constraints

The following constraints may affect the timing and scope of this project and should be re-evaluated prior to initiating:

- Blower improvements and expansion may be included as part of the Expansion Phase 1 Project if existing blowers are inhibiting the IFAS treatment process, and are determined to be in need of complete replacement prior to 2025.

9.3.3 Liquids Improvements Project Phase 1 (LIP1)

The goal of the Liquids Improvements Project Phase 1 (LIP1) is to expand the liquids stream capacity through the construction of a new clarifier, disc filter, and headworks screen. This project will provide the following key improvements:

- Addition of a third clarifier –
    - Assuming a conservative surface loading rate of 1,000 gpd/ft^2, based on Chapter 70 of the “Ten States Recommended Standards for Wastewater Facilities,” each clarifier is capable of processing up to nearly 3.8 MGD, giving a total capacity of 7.6 MGD. Influent flow projections show that the NWRF will exceed a maximum month flow of approximately 3.8 MGD by 2032, meaning a third clarifier will be required in order to provide firm capacity. This project will provide a third 70-ft diameter clarifier to receive effluent from the IFAS process, and construct second splitter structure to split flows between all three secondary clarifiers. A fourth clarifier will not be required within the next twenty years at the NWRF.
    - Expand RAS and associated pumping capacity as required to accommodate the third secondary clarifier addition.
- Second Disc Filter –
    - The NWRF’s existing disc filter is capable of processing a maximum month flow of 3.6 MGD. No redundant unit exists for the disc filter, but the NWRF may use

only the UV system and discharge to Boulder Creek during disc filter downtime. Projected influent flows to the NWRF show that the effluent flows may exceed 3.6 MGD by 2032. At this point, a second disc filter will be required to provide the necessary total capacity.
    - Expand the UV/Dewatering Building to the west in order to accommodate a second disc filter, and leave room for UV system expansion. Provide means for effluent from both UV channels to flow to both disc filters.
- Second Headworks Screen –
    - The NWRF's existing influent Headworks screen has a maximum month capacity of 4.2 MGD. No redundant Headworks mechanical screen is provided, but the NWRF can send influent to the manual bar screen while the mechanical Headworks screen is down for maintenance. Projected influent flows show that the NWRF may exceed a maximum month influent flow of 4.2 MGD by the year 2035. To provide the required total capacity for the influent screen, construct a second mechanical Headworks screen in the third influent channel. The manual bar screen should remain in place to provide additional redundancy.

Project Triggers

The goals for this project are to provide the necessary equipment capacity to manage increasing influent flows to the NWRF. Additionally, improvements that cannot be included in the EP1 project due to budgetary constraints are captured in this project.

Project Schedule

This project is recommended to begin design in 2028 with construction finishing by the end of 2030 and the new facilities being commissioned and put into service by 2031.

Project Constraints

The following constraints may affect the timing and scope of this project and should be re-evaluated prior to initiating:

- The second disc filter or second Headworks screen may already be included in EP1 as bid alternates, if the project budget allows. In this case they may be eliminated from the scope of the LIP1 project.

9.3.4 Liquids Improvements Project Phase 2 (LIP2)

The goal of the Liquids Improvements Project Phase 2 (LIP2) is to provide improvements and expansions for the liquids stream that were not captured in LIP1. Necessary improvements include:

- UV System Expansion –
    - The NWRF's existing UV system is capable of processing 4.2 MGD maximum month influent flow per bank, for a total capacity of 8.4 MGD. Influent flow projections show that UV expansion is required by 2035, in order to ensure complete process redundancy. Since the LIP1 project will have already expanded the UV/Dewatering Building to accommodate a second filter, the UV expansion should remain in this building.

  - Provide necessary changes to route flow from each UV bank to each disc filter.

Project Triggers

The goals for this project are to provide the necessary equipment capacity to manage increasing influent flows to the NWRF.

Project Schedule

This project is recommended to begin design in 2032 with construction finishing by the end of 2033.

Project Constraints

The following constraints may affect the timing and scope of this project and should be re-evaluated prior to initiating:

- Potential re-rating of UV system due to bulb replacement
- If the budget of the LIP1 project allows for UV expansion, this project may be performed sooner than 2032.

9.3.5 Expansion Project Phase 2 (EP2)

The goal of the Plant Expansion Project Phase 2 is to provide the necessary treatment and infrastructure expansions to meet projected 2038 influent flows and loads. This project will provide the following key improvements:

- Fourth IFAS Train –
  - A fourth IFAS train is required to meet 2038 flows and loads demands. The fourth IFAS train will be serviced by the second grit chamber installed in the EP1 project, and will also be identical to the NWRF's existing three IFAS trains.
  - RAS and IR pumping should be expanded as necessary to meet the required flow demands. Additionally, a second grit dewaterer/classifier should be added as part of this project if it is not included in earlier projects due to budget constraints.
  - Blower capacity expansion should be provided to provide the necessary aeration to all four IFAS trains.
- ATAD Facility Expansion –
  - The ATAD facility will be expanded to meet 2038 conditions. This expansion will include a third ThermAer tank and a second SNDR tank. The building will also be expanded to house the necessary pumping and equipment additions as part of this expansion.

Project Triggers

This project is driven by capacity requirements for 2038 conditions, as well as any future treatment limits imposed by future permits and regulations. Since the NWRF is registered for Policy 17-1 incentives, the compliance schedule should be extended to 2042 for Regulation 31, as long as the NWRF can provide proof of effluent data complying with the incentive limits.

Project Schedule

This project is recommended to be designed in 2033 with construction finishing by the end of 2035.

Project Constraints

The following constraints may affect the timing and scope of this project and should be re-evaluated prior to initiating:

- Regulation 31 timing and Policy 17-1 compliance schedule
- Variation between projected and actual influent flows and loads

9.3.6 Master Plan Updates

It is recommended the Town conduct periodic master plan updates for the NWRF. In this manner, the Town is able to review and update previous planning and assumptions. It also allows the Town to update process assumptions based on updated regulations and permit conditions. Finally, it allows the Town to stay current on emerging issues and technologies.

9.4 High-Level Project Cost Estimates

HDR has provided a high-level cost estimate for each of the projects listed and discussed above, in order to give the Town a general idea for the order of magnitude costs for each project. Table 9-2 below shows a summary of anticipated project costs.

Table 9-2. High-Level Budgetary Estimates for Anticipated Projects

Item	Cost Estimate
Plant Expansion Project Phase 1	$25M
Miscellaneous Improvements Project	$1M
Liquids Improvement Project Phase 1	$5M
Liquids Improvement Project Phase 2	$1M
Plant Expansion Project Phase 2	$15M
Master Plan Update[a]	$200K[a]

[a] This estimate represents the cost per single Master Plan Update

9.5 Proposed Wastewater Infrastructure Improvements CIP

HDR has developed a proposed wastewater infrastructure improvements CIP for the Erie NWRF based on the recommended projects noted previously. Figure 9-1 provides the triggers, drivers, permit phasing and proposed projects. Triggers and/or drivers associated with a specific project are color coded. The proposed layout of the facilities identified in the CIP is shown on Figure 9-2. Project numbers are shown on the map with a description in the key.

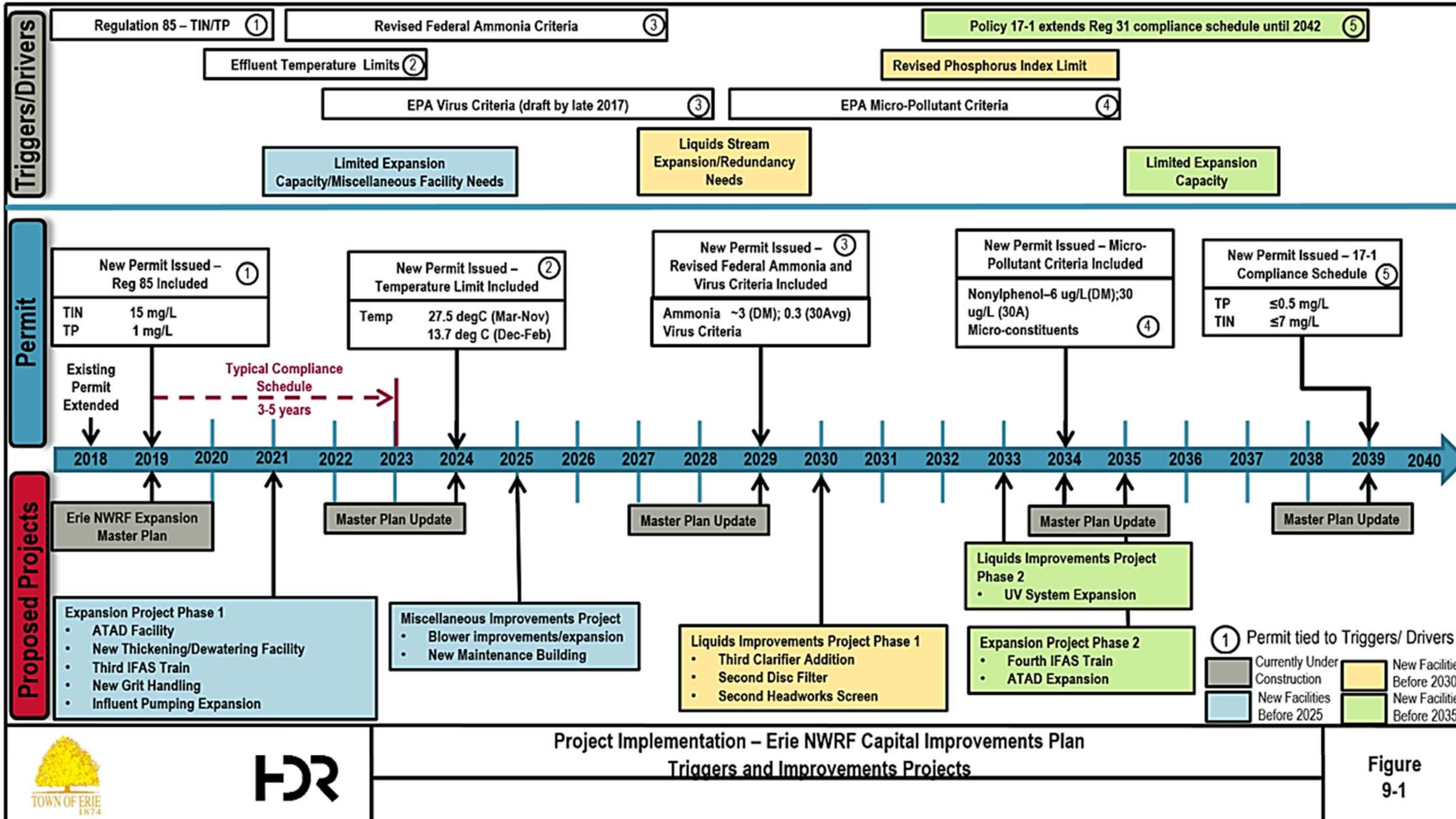


Figure 9-1. Triggers and Improvements Projects

This page is intentionally left blank.

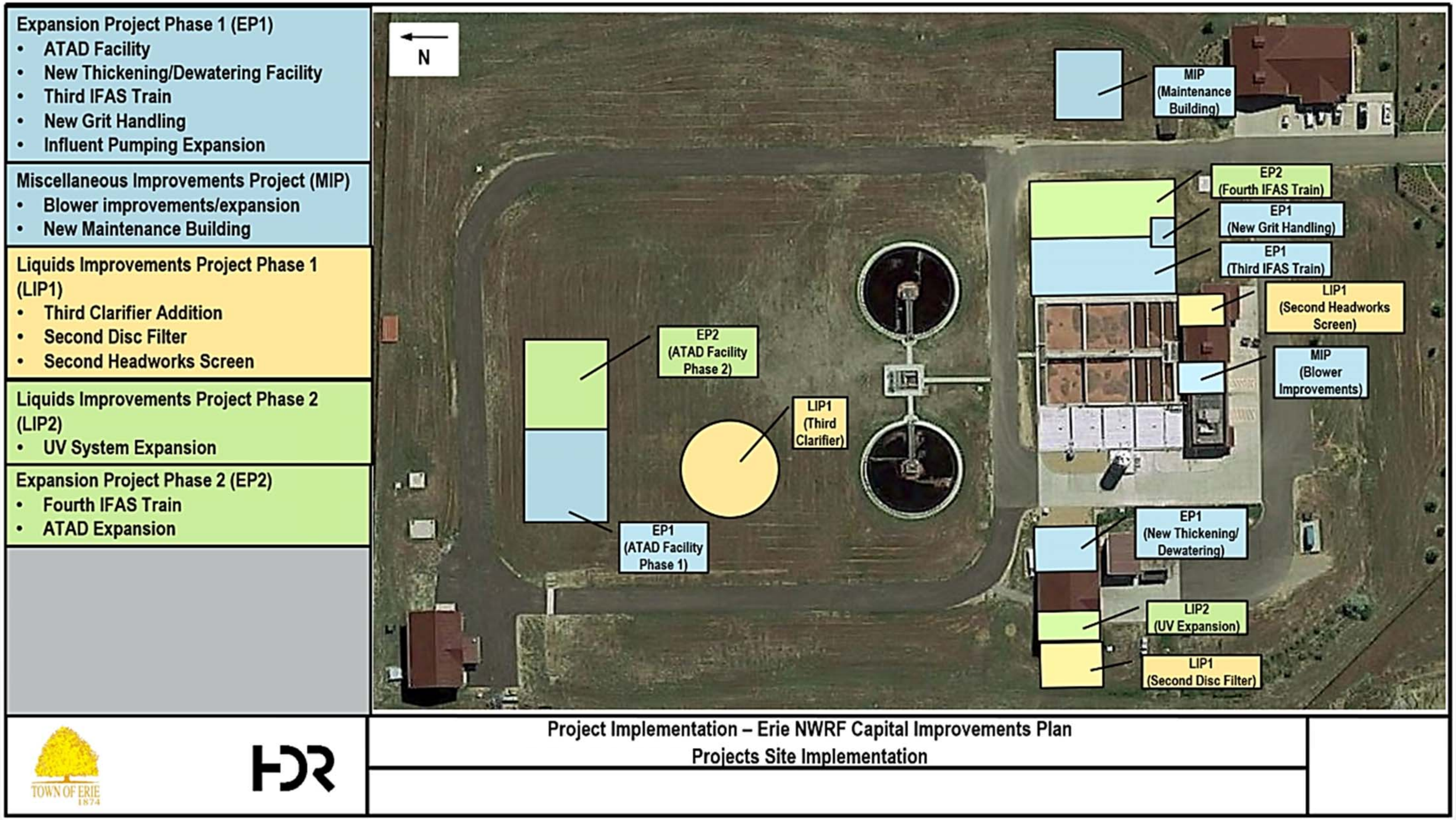


Figure 9-2. Projects Site Implementation

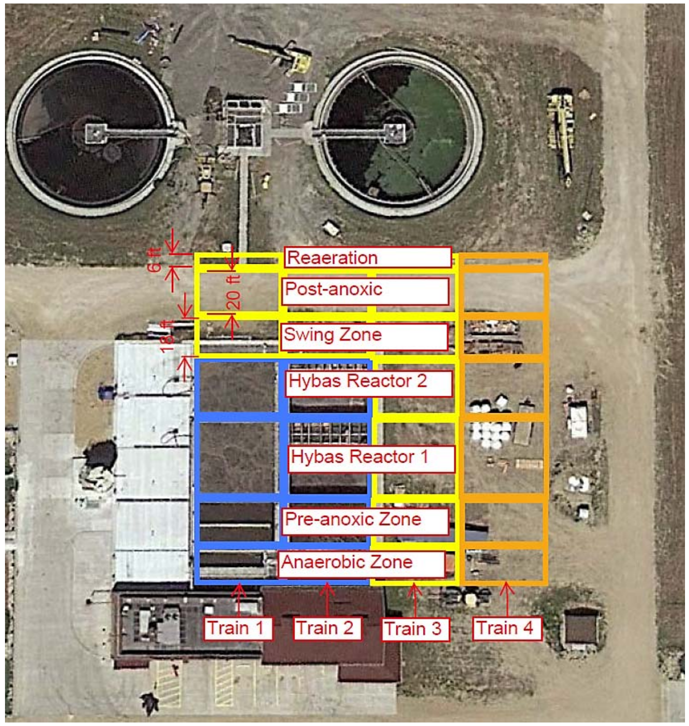
This page is intentionally left blank.

Appendix A: Liquid Stream Cost Estimates

Opinion of Probable Construction Cost

Town of Erie Master Plan - Liquid Stream Alternative 1 - Expand IFAS						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 316,867	
	Bonds and Insurance	3%	%		$ 135,800	
				General Conditions Subtotal	***$ 452,668***	
Div 2	**Sitework**					
	Demolition and Site Preparation	1	LS	$ 25,000	$ 25,000	
	Dewatering	1	LS	$ 40,000	$ 40,000	
	Excavation	8,558	CY	$ 10	$ 85,583	
	Backfill	1,712	CY	$ 20	$ 34,233	
	Paving	100	SY	$ 45	$ 4,500	
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	500	LF	$ 60	$ 30,000	
	Site Utilities	1	LS	$ 20,000	$ 20,000	
	Landscaping and Restoration	1	LS	$ 10,000	$ 10,000	
				Sitework Subtotal	***$ 254,317***	
Div 3	**Concrete**					
Train 1 - Swing/Post-Anoxic/Rearation						
	Slab	127	CY	$ 750	$ 95,333	
	Walls	228	CY	$ 850	$ 193,611	
Train 2 - Swing/Post-Anoxic/Rearation						
	Slab	127	CY	$ 750	$ 95,333	
	Walls	179	CY	$ 850	$ 152,056	
Train 3 - Anaerobic/Pre-Anoxic/Hybas 1/Hybas 2/Swing/Post-Anoxic/Reaeration						
	Slab	430	CY	$ 750	$ 322,833	
	Walls	561	CY	$ 850	$ 476,944	
Train 3 - Grit Tank						
	Slab	50	CY	$ 750	$ 37,500	
	Walls	100	CY	$ 850	$ 85,000	
				Concrete Subtotal	***$ 1,458,611***	
Div 4	**Masonry**					
	None					
				Masonry Subtotal	***$ -***	
Div 5	**Metals**					
	None					
				Metals Subtotal	***$ -***	
Div 7	**Thermal and Moisture Protection**					
	Dampproofing	1	LS	$ 15,000	$ 15,000	
				Thermal and Moisture Protection Subtotal	***$ 15,000***	
Div 8	**Doors and Windows**					
	None					
				Doors and Windows Subtotal	***$ -***	
Div 9	**Finishes**					
	None					
				Finishes Subtotal	***$ -***	
Div 10	**Specialties**					
	Foam Mitigation System	1	LS	$ 35,000	$ 35,000	
				Specialties Subtotal	***$ 35,000***	

Div 11	**Equipment**					
	Kruger IFAS Expansion (Media, retention screens, aeration system, valves, IMLR pumps, submersible mixers, PLC, DO probes, Flow meters)	1	LS	$ 1,200,000	$ 1,200,000	From Kruger Quote
	IMLR Pumps for Trains 1 and 2 (Train 3 Provided by Kruger)	2	EA	$ 20,000	$ 40,000	Estimate from Bozeman escalated
	Grit Tank	1	LS	$ 140,000	$ 140,000	From Hydro International Quote (10-11-18)
	Grit Pump	2	EA	$ 10,000	$ 20,000	Estimate
	Fourth Influent Pump	1	EA	$ 65,000	$ 65,000	Estimate
	Second WAS Pump	1	EA	$ 15,000	$ 15,000	Estimate
	Installation	30%	%	$ 444,000	$ 444,000	
				Equipment Subtotal	***$ 1,924,000***	
Div 13	**Special Construction**					
	None				$ -	
				Special Construction Subtotal	***$ -***	
Div 15	**Mechanical**					
	Train 1 Piping & Valves	1	LS	$ 45,000	$ 45,000	Estimate
	Train 2 Piping & Valves	1	LS	$ 45,000	$ 45,000	Estimate
	Train 3 Piping & Valves	1	LS	$ 105,000	$ 105,000	Estimate
	Influent Piping Modifications	1	LS	$ 85,000	$ 85,000	Estimate
	Installation	30%	%	$ 84,000	$ 84,000	
				Mechanical Subtotal	***$ 280,000***	
				BASE CONSTRUCTION SUBTOTAL	***$ 4,420,000***	
Div 16	**Electrical and Controls**					
	Electrical	15%	%	$ 335,850	$ 335,850	
	Instrumentation, Controls and Programming	10%	%	$ 223,900	$ 223,900	HDR provides programming
				Electrical and Instrumentation Subtotal	***$ 559,750***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 4,980,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 1,494,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 647,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 7,121,000***	
	Engineering Design/Construction Services	20%			$ 1,424,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 8,547,000***	
	Town Project Contingency	5%			$ 427,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 8,974,000**	



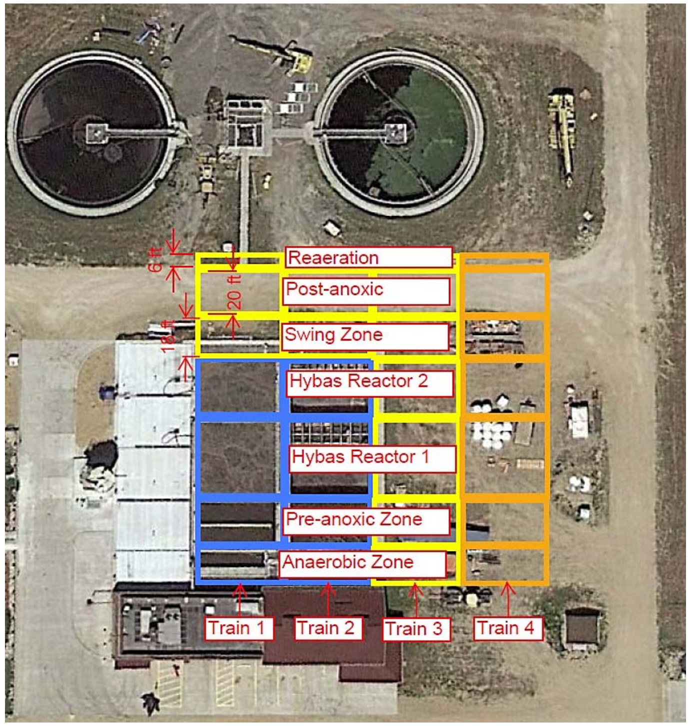
Tank Sizing-

Anaerobic Zone	Length	16.5	FT	Area	643.5	SF							
	Width	39	FT	Volume	11583	CF							
	Depth	18	FT	Wall Area	1890	SF							
Pre-Anoxic Zone	Length	20.5	FT	Area	799.5	SF							
	Width	39	FT		14391	CF							
	Depth	18	FT	Wall Area	1190	SF							
Hybas Reactor 1	Length	34	FT	Area	1326	SF							
	Width	39	FT		23868	CF							
	Depth	18	FT	Wall Area	1460	SF							
Hybas Reactor 2	Length	34	FT	Area	1326	SF							
	Width	39	FT		23868	CF							
	Depth	18	FT	Wall Area	1460	SF							
Swing Zone	Length	18	FT	Area	702	SF	Swing Zon	Length	18	FT	Area	702	SF
	Width	39	FT		12636	CF		Width	39	FT		12636	CF
	Depth	18	FT	Wall Area	1500	SF		Depth	18	FT	Wall Area	1140	SF
Post Anoxic	Length	20	FT	Area	780	SF	Post Anoxi	Length	20	FT	Area	780	SF
	Width	39	FT		14040	CF		Width	39	FT		14040	CF
	Depth	18	FT	Wall Area	1580	SF		Depth	18	FT	Wall Area	1180	SF
Reaeration	Length	6	FT	Area	234	SF	Reaeratior	Length	6	FT	Area	234	SF
	Width	39	FT		4212	CF		Width	39	FT		4212	CF
	Depth	18	FT	Wall Area	1020	SF		Depth	18	FT	Wall Area	900	SF

Opinion of Probable Construction Cost

Town of Erie Master Plan - Liquid Stream Alternative 2 - Expand IFAS with Secondary Priorities						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 356,111	
	Bonds and Insurance	3%	%		$ 152,619	
				General Conditions Subtotal	***$ 508,730***	
Div 2	**Sitework**					
	Demolition and Site Preparation	1	LS	$ 25,000	$ 25,000	
	Dewatering	1	LS	$ 40,000	$ 40,000	
	Excavation	8,558	CY	$ 10	$ 85,583	
	Backfill	1,712	CY	$ 20	$ 34,233	
	Paving	100	SY	$ 45	$ 4,500	
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	500	LF	$ 60	$ 30,000	
	Site Utilities	1	LS	$ 20,000	$ 20,000	
	Landscaping and Restoration	1	LS	$ 10,000	$ 10,000	
				Sitework Subtotal	***$ 254,317***	
Div 3	**Concrete**					
Train 1 - Swing/Post-Anoxic/Rearation						
	Slab	127	CY	$ 750	$ 95,333	
	Walls	228	CY	$ 850	$ 193,611	
Train 2 - Swing/Post-Anoxic/Rearation						
	Slab	127	CY	$ 750	$ 95,333	
	Walls	179	CY	$ 850	$ 152,056	
Train 3 - Anaerobic/Pre-Anoxic/Hybas 1/Hybas 2/Swing/Post-Anoxic/Reaeration						
	Slab	430	CY	$ 750	$ 322,833	
	Walls	561	CY	$ 850	$ 476,944	
Train 3 - Grit Tank						
	Slab	50	CY	$ 750	$ 37,500	
	Walls	100	CY	$ 850	$ 85,000	
				Concrete Subtotal	***$ 1,458,611***	
Div 4	**Masonry**					
	None					
				Masonry Subtotal	***$ -***	
Div 5	**Metals**					
	None					
				Metals Subtotal	***$ -***	
Div 7	**Thermal and Moisture Protection**					
	Dampproofing	1	LS	$ 15,000	$ 15,000	
				Thermal and Moisture Protection Subtotal	***$ 15,000***	
Div 8	**Doors and Windows**					
	None					
				Doors and Windows Subtotal	***$ -***	
Div 9	**Finishes**					
	None					
				Finishes Subtotal	***$ -***	
Div 10	**Specialties**					
	Foam Mitigation System	1	LS	$ 35,000	$ 35,000	
				Specialties Subtotal	***$ 35,000***	

Div 11	**Equipment**					
	Kruger IFAS Expansion (Media, retention screens, aeration system, valves, IMLR pumps, submersible mixers, PLC, DO probes, Flow meters)	1	LS	$ 1,200,000	$ 1,200,000	From Kruger Quote
	IMLR Pumps for Trains 1 and 2 (Train 3 Provided by Kruger)	2	EA	$ 20,000	$ 40,000	Estimate from Bozeman
	Grit Tank	1	LS	$ 140,000	$ 140,000	Quote from Hydro International (10-11-18)
	Grit Pump	2	EA	$ 10,000	$ 20,000	Estimate
	Fourth Influent Pump	1	EA	$ 65,000	$ 65,000	Estimate
	Second WAS Pump	1	EA	$ 15,000	$ 15,000	Estimate
	Fourth Turbo Blower	1	EA	$ 170,000	$ 170,000	Quote from Aerzen
	Second Grit Washer/Classsifier	1	EA	$ 175,000	$ 175,000	Quote from Hydro International (10-11-18)
	Installation	30%	%	$ 547,500	$ 547,500	
				Equipment Subtotal	***$ 2,372,500***	
Div 13	**Special Construction**					
	None				$ -	
				Special Construction Subtotal	***$ -***	
Div 15	**Mechanical**					
	Train 1 Piping & Valves	1	LS	$ 45,000	$ 45,000	Estimate
	Train 2 Piping & Valves	1	LS	$ 45,000	$ 45,000	Estimate
	Train 3 Piping & Valves	1	LS	$ 105,000	$ 105,000	Estimate
	Influent Piping Modifications	1	LS	$ 85,000	$ 85,000	Estimate
	Installation	30%	%	$ 84,000	$ 84,000	
				Mechanical Subtotal	***$ 280,000***	
				BASE CONSTRUCTION SUBTOTAL	***$ 4,924,000***	
Div 16	**Electrical and Controls**					
	Electrical	15%	%	$ 403,125	$ 403,125	
	Instrumentation, Controls and Programming	10%	%	$ 268,750	$ 268,750	HDR provides programming
				Electrical and Instrumentation Subtotal	***$ 671,875***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 5,596,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 1,679,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 728,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 8,003,000***	
	Engineering Design/Construction Services	20%			$ 1,601,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 9,606,000***	
	Town Project Contingency	5%			$ 480,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 10,086,000**	



Tank Sizing-

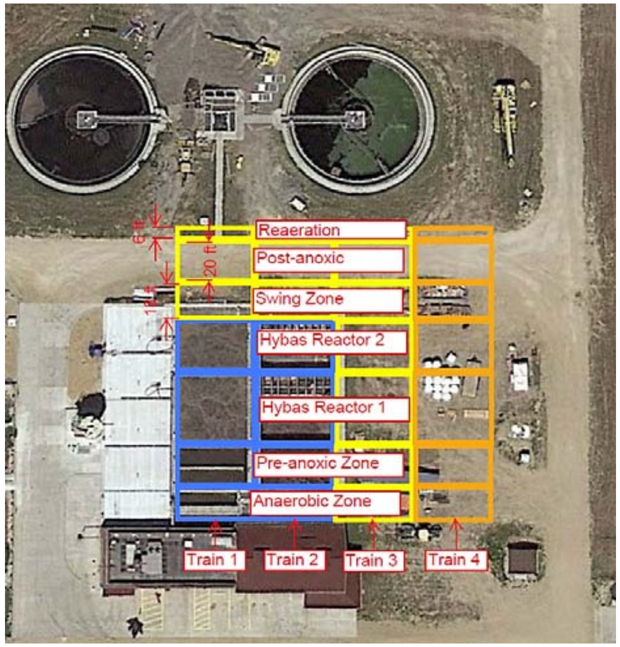
Anaerobic Zone	Length	16.5	FT	Area	643.5	SF
	Width	39	FT	Volume	11583	CF
	Depth	18	FT	Wall Area	1890	SF
Pre-Anoxic Zone	Length	20.5	FT	Area	799.5	SF
	Width	39	FT		14391	CF
	Depth	18	FT	Wall Area	1190	SF
Hybas Reactor 1	Length	34	FT	Area	1326	SF
	Width	39	FT		23868	CF
	Depth	18	FT	Wall Area	1460	SF
Hybas Reactor 2	Length	34	FT	Area	1326	SF
	Width	39	FT		23868	CF
	Depth	18	FT	Wall Area	1460	SF
Swing Zone	Length	18	FT	Area	702	SF
	Width	39	FT		12636	CF
	Depth	18	FT	Wall Area	1500	SF
Post Anoxic	Length	20	FT	Area	780	SF
	Width	39	FT		14040	CF
	Depth	18	FT	Wall Area	1580	SF
Reaeration	Length	6	FT	Area	234	SF
	Width	39	FT		4212	CF
	Depth	18	FT	Wall Area	1020	SF

Swing Zon	Length	18	FT	Area	702	SF
	Width	39	FT		12636	CF
	Depth	18	FT	Wall Area	1140	SF
Post Anoxi	Length	20	FT	Area	780	SF
	Width	39	FT		14040	CF
	Depth	18	FT	Wall Area	1180	SF
Reaeratior	Length	6	FT	Area	234	SF
	Width	39	FT		4212	CF
	Depth	18	FT	Wall Area	900	SF

Opinion of Probable Construction Cost

Town of Erie Master Plan - Liquid Stream Alternative 3 - Expand IFAS with Tertiary Priorities (Expand Disinfection Building)						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 418,694	
	Bonds and Insurance	3%	%		$ 179,440	
				General Conditions Subtotal	***$ 598,135***	
Div 2	**Sitework**					
	Demolition and Site Preparation	1	LS	$ 25,000	$ 25,000	
	Dewatering	1	LS	$ 40,000	$ 40,000	
	Excavation	8,675	CY	$ 10	$ 86,750	
	Backfill	1,758	CY	$ 20	$ 35,167	
	Paving	100	SY	$ 45	$ 4,500	
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	500	LF	$ 60	$ 30,000	
	Site Utilities	1	LS	$ 20,000	$ 20,000	
	Landscaping and Restoration	1	LS	$ 10,000	$ 10,000	
				Sitework Subtotal	***$ 256,417***	
Div 3	**Concrete**					
Train 1 - Swing/Post-Anoxic/Rearation						
	Slab	127	CY	$ 750	$ 95,333	
	Walls	228	CY	$ 850	$ 193,611	
Train 2 - Swing/Post-Anoxic/Rearation						
	Slab	127	CY	$ 750	$ 95,333	
	Walls	179	CY	$ 850	$ 152,056	
Train 3 - Anaerobic/Pre-Anoxic/Hybas 1/Hybas 2/Swing/Post-Anoxic/Reaeration						
	Slab	430	CY	$ 750	$ 322,833	
	Walls	561	CY	$ 850	$ 476,944	
Train 3 - Grit Tank						
	Slab	50	CY	$ 750	$ 37,500	
	Walls	100	CY	$ 850	$ 85,000	
UV Building Expansion						
	Slab	23	CY	$ 750	$ 17,500	
				Concrete Subtotal	***$ 1,458,611***	
Div 4	**Masonry**					
UV Building Expansion - 42'x15'						
	CMU Block-Exterior (12" structural block)	1,512	SF	$ 35	$ 52,920	12" block
				Masonry Subtotal	***$ 52,920***	
Div 5	**Metals**					
	UV Building Expansion Roof Trusses	1	LS	$ 15,000	$ 15,000	
	UV Building Metal Roof	630	SF	$ 25	$ 15,750	
				Metals Subtotal	***$ 30,750***	
Div 7	**Thermal and Moisture Protection**					
	Dampproofing	1	LS	$ 15,000	$ 15,000	
	Roof Insulation	630	SF	$ 5	$ 3,150	
				Thermal and Moisture Protection Subtotal	***$ 18,150***	
Div 8	**Doors and Windows**					
	Doors and Windows	1	LS	$ 15,000	$ 15,000	
	Overhead Rolling Door	1	LS	$ 12,000	$ 12,000	
				Doors and Windows Subtotal	***$ 27,000***	
Div 9	**Finishes**					
	None					
				Finishes Subtotal	***$ -***	

Div 10	**Specialties**					
	Foam Mitigation System	1	LS	$ 35,000	$ 35,000	
				Specialties Subtotal	***$ 35,000***	
Div 11	**Equipment**					
	Kruger IFAS Expansion (Media, retention screens, aeration system, valves, IMLR pumps, submersible mixers, PLC, DO probes, Flow meters)	1	LS	$ 1,200,000	$ 1,200,000	From Kruger Quote
	IMLR Pumps for Trains 1 and 2 (Train 3 Provided by Kruger)	2	EA	$ 20,000	$ 40,000	Estimate from Bozeman
	Grit Tank	1	LS	$ 140,000	$ 140,000	Quote from Hydro International (10-11-18)
	Grit Pump	2	EA	$ 10,000	$ 20,000	Estimate
	Fourth Influent Pump	1	EA	$ 65,000	$ 65,000	Estimate
	Second WAS Pump	1	EA	$ 15,000	$ 15,000	Estimate
	Fourth Turbo Blower	1	EA	$ 170,000	$ 170,000	Quote from Aerzen
	Second Grit Washer/Classsifier	1	EA	$ 175,000	$ 175,000	Quote from Hydro International (10-11-18)
	Second Disc Filer	1	EA	$ 255,000	$ 255,000	Quote from Kruger (10-11-18)
	Second Headworks Band Screen and Washer Compactor	1	EA	$ 220,000	$ 220,000	Quote from JWC (10-11-18)
	Installation	30%	%	$ 690,000	$ 690,000	
				Equipment Subtotal	***$ 2,990,000***	
Div 13	**Special Construction**					
	None				$ -	
				Special Construction Subtotal	***$ -***	
Div 15	**Mechanical**					
	Train 1 Piping & Valves	1	LS	$ 45,000	$ 45,000	Estimate
	Train 2 Piping & Valves	1	LS	$ 45,000	$ 45,000	Estimate
	Train 3 Piping & Valves	1	LS	$ 105,000	$ 105,000	Estimate
	Influent Piping Modifications	1	LS	$ 85,000	$ 85,000	Estimate
	UV Building Expansion Plumbing	1	LS	$ 5,000	$ 5,000	Estimate
	UV Building Expansion HVAC	1	LS	$ 10,000	$ 10,000	Estimate
	Installation	30%	%	$ 88,500	$ 88,500	
				Mechanical Subtotal	***$ 285,000***	
				BASE CONSTRUCTION SUBTOTAL	***$ 5,752,000***	
Div 16	**Electrical and Controls**					
	Electrical	15%	%	$ 496,500	$ 496,500	
	Instrumentation, Controls and Programming	10%	%	$ 331,000	$ 331,000	HDR provided programming
				Electrical and Instrumentation Subtotal	***$ 827,500***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 6,580,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 1,974,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 855,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 9,409,000***	
	Engineering Design/Construction Services	20%			$ 1,882,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 11,293,000***	
	Town Project Contingency	5%			$ 565,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 11,858,000**	

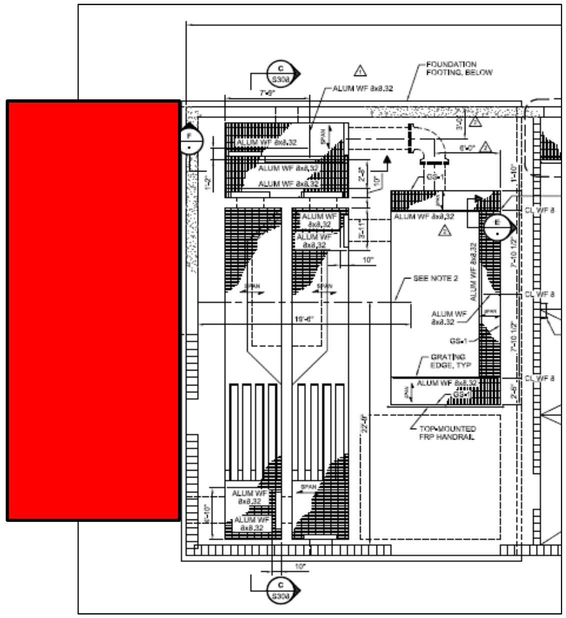


Tank Sizing-

Anaerobic Zone	Length	16.5	FT	Area	643.5	SF
	Width	39	FT	Volume	11583	CF
	Depth	18	FT	Wall Area	1890	SF
Pre-Anoxic Zone	Length	20.5	FT	Area	799.5	SF
	Width	39	FT		14391	CF
	Depth	18	FT	Wall Area	1190	SF
Hybas Reactor 1	Length	34	FT	Area	1326	SF
	Width	39	FT		23868	CF
	Depth	18	FT	Wall Area	1460	SF
Hybas Reactor 2	Length	34	FT	Area	1326	SF
	Width	39	FT		23868	CF
	Depth	18	FT	Wall Area	1460	SF
Swing Zone	Length	18	FT	Area	702	SF
	Width	39	FT		12636	CF
	Depth	18	FT	Wall Area	1500	SF
Post Anoxic	Length	20	FT	Area	780	SF
	Width	39	FT		14040	CF
	Depth	18	FT	Wall Area	1580	SF
Reaeration	Length	6	FT	Area	234	SF
	Width	39	FT		4212	CF
	Depth	18	FT	Wall Area	1020	SF

Swing Zon	Length	18	FT	Area	702	SF
	Width	39	FT		12636	CF
	Depth	18	FT	Wall Area	1140	SF
Post Anoxi	Length	20	FT	Area	780	SF
	Width	39	FT		14040	CF
	Depth	18	FT	Wall Area	1180	SF
Reaeratior	Length	6	FT	Area	234	SF
	Width	39	FT		4212	CF
	Depth	18	FT	Wall Area	900	SF

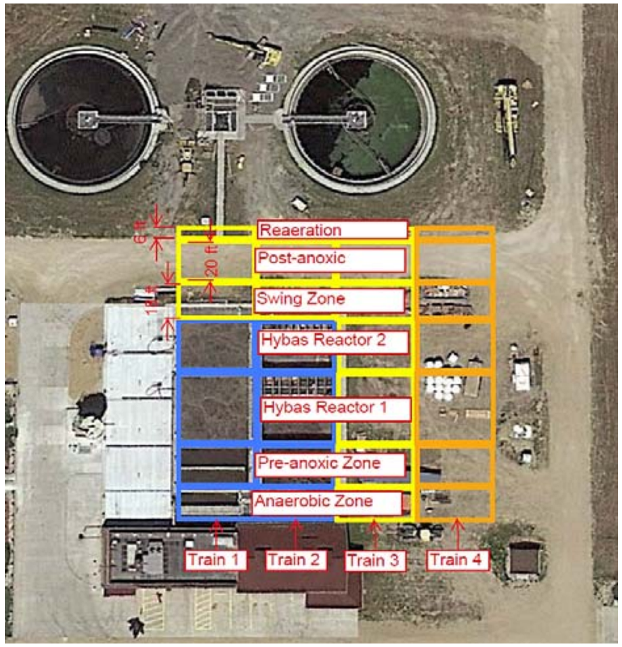
UV Building Expansion		
Width	42	FT
Additional Length	15	FT
Height	21	FT



Opinion of Probable Construction Cost

Town of Erie Master Plan - Liquid Stream Alternative 4 - Expand IFAS with Tertiary Priorities (No Expansion of Disinfection Building)						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 413,264	
	Bonds and Insurance	3%	%		$ 177,113	
				General Conditions Subtotal	***$ 590,378***	
Div 2	**Sitework**					
	Demolition and Site Preparation	1	LS	$ 25,000	$ 25,000	
	Dewatering	1	LS	$ 40,000	$ 40,000	
	Excavation	8,675	CY	$ 10	$ 86,750	
	Backfill	1,758	CY	$ 20	$ 35,167	
	Paving	100	SY	$ 45	$ 4,500	
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	500	LF	$ 60	$ 30,000	
	Site Utilities	1	LS	$ 20,000	$ 20,000	
	Landscaping and Restoration	1	LS	$ 10,000	$ 10,000	
				Sitework Subtotal	***$ 256,417***	
Div 3	**Concrete**					
Train 1 - Swing/Post-Anoxic/Rearation						
	Slab	127	CY	$ 750	$ 95,333	
	Walls	228	CY	$ 850	$ 193,611	
Train 2 - Swing/Post-Anoxic/Rearation						
	Slab	127	CY	$ 750	$ 95,333	
	Walls	179	CY	$ 850	$ 152,056	
Train 3 - Anaerobic/Pre-Anoxic/Hybas 1/Hybas 2/Swing/Post-Anoxic/Reaeration						
	Slab	430	CY	$ 750	$ 322,833	
	Walls	561	CY	$ 850	$ 476,944	
Train 3 - Grit Tank						
	Slab	50	CY	$ 750	$ 37,500	
	Walls	100	CY	$ 850	$ 85,000	
Disc Filter Expansion						
	Slab	23	CY	$ 750	$ 17,500	
				Concrete Subtotal	***$ 1,458,611***	
Div 4	**Masonry**					
	None					
				Masonry Subtotal	***$ -***	
Div 5	**Metals**					
	None					
				Metals Subtotal	***$ -***	
Div 7	**Thermal and Moisture Protection**					
	Dampproofing	1	LS	$ 15,000	$ 15,000	
				Thermal and Moisture Protection Subtotal	***$ 15,000***	
Div 8	**Doors and Windows**					
	None					
				Doors and Windows Subtotal	***$ -***	
Div 9	**Finishes**					
	None					
				Finishes Subtotal	***$ -***	

Div 10	**Specialties**					
	Foam Mitigation	1	LS	$ 25,000	$ 25,000	
				Specialties Subtotal	***$ 25,000***	
Div 11	**Equipment**					
	Kruger IFAS Expansion (Media, retention screens, aeration system, valves, IMLR pumps, submersible mixers, PLC, DO probes, Flow meters)	1	LS	$ 1,200,000	$ 1,200,000	From Kruger Quote
	IMLR Pumps for Trains 1 and 2 (Train 3 Provided by Kruger)	2	EA	$ 20,000	$ 40,000	Estimate from Bozeman
	Grit Tank	1	LS	$ 140,000	$ 140,000	Quote from Hydro International (10-11-18)
	Grit Pump	2	EA	$ 10,000	$ 20,000	Estimate
	Fourth Influent Pump	1	EA	$ 65,000	$ 65,000	Estimate
	Second WAS Pump	1	EA	$ 15,000	$ 15,000	Estimate
	Fourth Turbo Blower	1	EA	$ 170,000	$ 170,000	Quote from Aerzen
	Second Grit Washer/Classsifier	1	EA	$ 175,000	$ 175,000	Quote from Hydro International (10-11-18)
	Second Disc Filer-Self Contained	1	EA	$ 285,000	$ 285,000	Quote from Kruger (10-11-18)
	Second Headworks Band Screen and Washer Compactor	1	EA	$ 220,000	$ 220,000	Quote from JWC (10-11-18)
	Installation	30%	%	$ 699,000	$ 699,000	
				Equipment Subtotal	***$ 3,029,000***	
Div 13	**Special Construction**					
	None				$ -	
				Special Construction Subtotal	***$ -***	
Div 15	**Mechanical**					
	Train 1 Piping & Valves	1	LS	$ 45,000	$ 45,000	Estimate
	Train 2 Piping & Valves	1	LS	$ 45,000	$ 45,000	Estimate
	Train 3 Piping & Valves	1	LS	$ 105,000	$ 105,000	Estimate
	Influent Piping Modifications	1	LS	$ 85,000	$ 85,000	Estimate
	UV Building Expansion Plumbing	1	LS	$ 5,000	$ 5,000	Estimate
	UV Building Expansion HVAC	1	LS	$ 10,000	$ 10,000	Estimate
	Installation	30%	%	$ 88,500	$ 88,500	
				Mechanical Subtotal	***$ 285,000***	
				BASE CONSTRUCTION SUBTOTAL	***$ 5,659,000***	
Div 16	**Electrical and Controls**					
	Electrical	15%	%	$ 500,850	$ 500,850	
	Instrumentation, Controls and Programming	10%	%	$ 333,900	$ 333,900	HDR provides programming
				Electrical and Instrumentation Subtotal	***$ 834,750***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 6,494,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 1,948,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 844,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 9,286,000***	
	Engineering Design/Construction Services	20%			$ 1,857,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 11,145,000***	
	Town Project Contingency	5%			$ 557,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 11,702,000**	

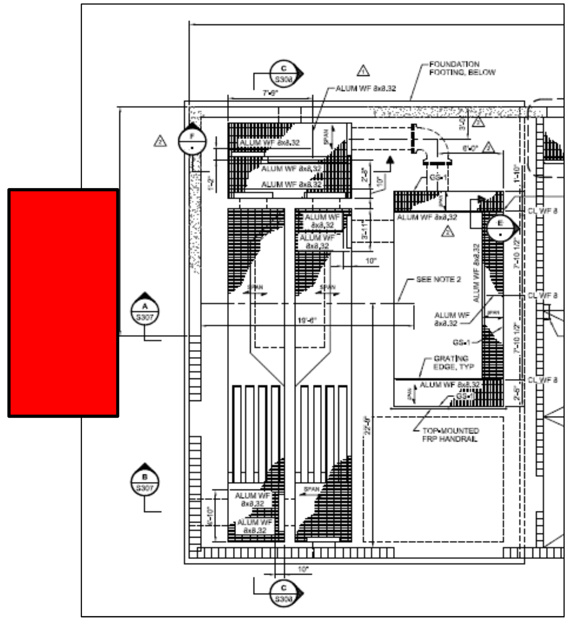


Tank Sizing-

Anaerobic Zone	Length	16.5	FT	Area	643.5	SF
	Width	39	FT	Volume	11583	CF
	Depth	18	FT	Wall Area	1890	SF
Pre-Anoxic Zone	Length	20.5	FT	Area	799.5	SF
	Width	39	FT		14391	CF
	Depth	18	FT	Wall Area	1190	SF
Hybas Reactor 1	Length	34	FT	Area	1326	SF
	Width	39	FT		23868	CF
	Depth	18	FT	Wall Area	1460	SF
Hybas Reactor 2	Length	34	FT	Area	1326	SF
	Width	39	FT		23868	CF
	Depth	18	FT	Wall Area	1460	SF
Swing Zone	Length	18	FT	Area	702	SF
	Width	39	FT		12636	CF
	Depth	18	FT	Wall Area	1500	SF
Post Anoxic	Length	20	FT	Area	780	SF
	Width	39	FT		14040	CF
	Depth	18	FT	Wall Area	1580	SF
Reaeration	Length	6	FT	Area	234	SF
	Width	39	FT		4212	CF
	Depth	18	FT	Wall Area	1020	SF

Swing Zon	Length	18	FT	Area	702	SF
	Width	39	FT		12636	CF
	Depth	18	FT	Wall Area	1140	SF
Post Anoxi	Length	20	FT	Area	780	SF
	Width	39	FT		14040	CF
	Depth	18	FT	Wall Area	1180	SF
Reaeratior	Length	6	FT	Area	234	SF
	Width	39	FT		4212	CF
	Depth	18	FT	Wall Area	900	SF

UV Building Expansion		
Width	42	FT
Additional Length	15	FT
Height	21	FT



Appendix A: Solids Stream Cost Estimates

Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan - ATAD (2028 Condition)						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 536,794	
	Bonds and Insurance	3%	%		$ 230,055	
				General Conditions Subtotal	***$ 766,849***	
Div 2	**Sitework**					
	Demolition and Site Preparation	1	LS	$ 10,000	$ 10,000	
	Dewatering	1	LS	$ 20,000	$ 20,000	
	Excavation	747	CY	$ 10	$ 7,467	96x70 size tanks and building, dig 3'
	Backfill	249	CY	$ 20	$ 4,978	96x70 size tanks and building, dig 3', replace 1'
	Paving	22	SY	$ 45	$ 1,000	Estimate - depends on location of new ATAD
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	1,000	LF	$ 100	$ 100,000	Estimate - depends on location of new ATAD
	Landscaping and Restoration	1	LS	$ 5,000	$ 5,000	
				Sitework Subtotal	***$ 153,444***	
Div 3	**Concrete**					
	ATAD Building Slab	440	CY	$ 500	$ 220,000	96x70 bldg, 30*40 biofilter, 1.5' deep slab
	Drilled Piers	1,120	LF	$ 350	$ 392,000	Piers
	ATAD Roof	249	CY	$ 1,000	$ 248,889	
	ATAD Tank Walls	756	CY	$ 750	$ 566,889	Building and tanks 24' tall - tank walls are concrete
				Concrete Subtotal	***$ 1,427,778***	
Div 4	**Masonry**					
	ATAD Building Exterior Veneer (8" block, insulation)	7,968	SF	$ 30	$ 239,040	
				Masonry Subtotal	***$ 239,040***	
Div 5	**Metals**					
	Misc. Metals, Grating and Platforms	1	LS	$ 10,000	$ 10,000	
				Metals Subtotal	***$ 10,000***	
Div 7	**Thermal and Moisture Protection**					
	EPDM Roofing	3,000	SF	$ 30	$ 90,000	
	Insulation	3,000	SF	$ 10	$ 30,000	
	Dampproofing	1	LS	$ 15,000	$ 15,000	
				Thermal and Moisture Protection Subtotal	***$ 135,000***	
Div 8	**Doors and Windows**					
	Roll-Up Doors	1	EA	$ 12,000	$ 12,000	
	Doors and Windows	1	LS	$ 20,000	$ 20,000	
				Doors and Windows Subtotal	***$ 32,000***	

Div 9	**Finishes**					
	Painting	1	LS	$ 30,000	$ 30,000	
				Finishes Subtotal	***$ 30,000***	
Div 10	**Specialties**					
	None					
				Specialties Subtotal	***$ -***	
Div 11	**Equipment**					
	ATAD System Equipment	1	LS	$ 2,822,251	$ 2,822,251	Quote from TPS
	Dewatering System Improvements	1	LS	$ 370,000	$ 370,000	Includes 2 new dewatering units, polymer system
	Thickening System Improvements	1	LS	$ 275,000	$ 275,000	Includes 2 new thickening units, TWAS pumps, polymer system upgrades
	WAS Pump	1	EA	$ 15,000	$ 15,000	
	Installation	30%	%	$ 1,044,675	$ 1,044,675	
				Equipment Subtotal	***$ 4,526,926***	
Div 13	**Special Construction**					
	Bridge Crane (Dewatering)	1	LS	$ 100,000	$ 100,000	
	Trolley and Hoist (ATAD)	1	LS	$ 25,000	$ 25,000	
				Special Construction Subtotal	***$ 125,000***	
Div 15	**Mechanical**					
	HVAC System	3,000	SF	$ 22	$ 66,000	Area of equipment/electrical room
	Plumbing	3,000	SF	$ 10	$ 30,000	Area of equipment/electrical room
	Piping & Valves	1	LS	$ 45,000	$ 45,000	
	Installation	30%	%	$ 42,300	$ 42,300	
				Mechanical Subtotal	***$ 183,300***	
				BASE CONSTRUCTION SUBTOTAL	***$ 7,629,000***	
Div 16	**Electrical and Controls**					
	Electrical and Controls	10%	%	$ 466,393	$ 466,393	TPS provides MCC, VFD, I&C equipment costs
	Instrumentation, Controls and Programming	7%	%	$ 339,306	$ 339,306	HDR provides programming
				Electrical and Instrumentation Subtotal	***$ 806,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 8,435,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 2,531,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 1,097,000	10% of Previous Subtotal

	TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL				***$ 12,063,000***	
	Engineering Design/Construction Services	20%			$ 2,413,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 2,000	$ 2,000	Base cost
	SUBTOTAL				***$ 14,478,000***	
	Town Project Contingency	5%			$ 724,000	5% of Subtotal
	TOTAL ANTICIPATED PROJECT COST (TAPC)				**$ 15,202,000**	

ANNUAL OPERATION AND MAINTENANCE COSTS						
Annual Costs - Current						
	O&M Personnel	2,920	hrs	$ 32	$ 93,440	8 hours per day
	Polymer	37	tote	$ 3,800	$ 138,700	Assumes similar polymer usage to existing system - one tote every 10 days
	Hauling Costs	756	ton	$ 240	$ 181,463	Assumes 4,143 lb/day hauled (2017 max month value)
	Total Energy Use	159	hp			Assumes 34% draw of total connected HP for 2028 system (ATAD components only - does not include dewatering equip)
	Electricity	1,038,641	kWh	$ 0.08	$ 83,091	
	Contingency	1	LS	$ 99,339	$ 99,339	20% Contingency
	Annual Cost Subtotal				**$ 596,034**	
Annual Costs - Future (2028)						Used **2028** for future annual costs, since 2038 annual costs would also be associated with additional capital costs, and the 20 year NPV wouldn't be accurate
	O&M Personnel	2,920	hrs	$ 40	$ 116,156	8 hours per day, costs inflated at 2.2% per year for 10 years
	Polymer	73	tote	$ 4,724	$ 344,838	Assumes similar increase in use as increase in solids - 2X the 2017 usage. Costs inflated at 2.2% per year for 10 years.
	Hauling Costs	1,537	ton	$ 298	$ 458,671	Assumes max month 2028 solids, 8,424 lb/d. Costs inflated at 2.2% per year for 10 years
	Total Energy Use	159	hp			Assumes 34% draw of total connected HP for 2028 system (ATAD components only - does not include dewatering equip)
	Electricity	1,038,641	kWh	$ 0.10	$ 103,291	Costs inflated at 2.2% per year for 10 years
	Contingency	1	LS	$ 204,591	$ 204,591	20% Contingency
	Annual Cost Subtotal				**$ 1,227,548**	
O&M COSTS NPV (2.1% discount rate over 10 years)					**$ 8,745,402**	
	Calculated to year 2028					
	TOTAL COSTS (10 Year NPV)				**$ 23,947,402**	

Operation and Maintenance Cost Summary

Discount Rate= 2.1%

		Cash Flows			
Year	Year #	Series (Annual Costs)	Single (Periodic Costs)	Results from Functions	
2018	0	$ 596,034		of series=	$8,745,402
2019	1	$ 659,185			
2020	2	$ 722,337		Present worth	
2021	3	$ 785,488		of singles=	$0.00
2022	4	$ 848,639			
2023	5	$ 911,791		Present worth	
2024	6	$ 974,942		total=	$8,745,402
2025	7	$ 1,038,094			
2026	8	$ 1,101,245			
2027	9	$ 1,164,397			
2028	10	$ 1,227,548			
2029	11				
2030	12				
2031	13				
2032	14				
2033	15				
2034	16				
2035	17				
2036	18				
2037	19				
2038	20				

Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan - ATAD (2038 Condition)						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 838,626	
	Bonds and Insurance	3%	%		$ 359,411	
				General Conditions Subtotal	***$ 1,198,037***	
Div 2	**Sitework**					
	Demolition and Site Preparation	1	LS	$ 15,000	$ 15,000	Increased from 2028 by $5k
	Dewatering	1	LS	$ 25,000	$ 25,000	Increased from 2028 by $5k
	Excavation	1502	CY	$ 10	$ 15,022	169 ft x 80 ft (TPS dwg) , dig 3 ft
	Backfill	501	CY	$ 20	$ 10,015	169 ft x 80 ft size tanks and building, dig 2', replace 1'
	Paving	22	SY	$ 45	$ 1,000	Estimate - depends on location of new ATAD
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	1,000	LF	$ 100	$ 100,000	Estimate - depends on location of new ATAD
	Landscaping and Restoration	1	LS	$ 5,000	$ 5,000	
				Sitework Subtotal	***$ 176,037***	
Div 3	**Concrete**					
	ATAD Building Slab	818	CY	$ 500	$ 408,889	96x70 bldg, 30*40 biofilter, 1.5' deep slab
	Drilled Piers	1,840	LF	$ 350	$ 644,000	Piers - assumes 46 piers for expanded ATAD
	ATAD Roof	501	CY	$ 1,000	$ 500,741	
	ATAD Tank Walls	1,328	CY	$ 750	$ 995,889	Building and tanks 24' tall - tank walls are concrete
				Concrete Subtotal	***$ 2,549,519***	
Div 4	**Masonry**					
	ATAD Building Exterior Veneer (8" block, insulation)	11,952	SF	$ 30	$ 358,560	
				Masonry Subtotal	***$ 358,560***	
Div 5	**Metals**					
	Misc. Metals, Grating and Platforms	1	LS	$ 15,000	$ 15,000	Increased from 2028 by $5k
				Metals Subtotal	***$ 15,000***	
Div 7	**Thermal and Moisture Protection**					
	EPDM Roofing	5,070	SF	$ 30	$ 152,100	Area of electrical/equipment room (169 ft x 30 ft)
	Insulation	5,070	SF	$ 10	$ 50,700	Area of electrical/equipment room (169 ft x 30 ft)
	Dampproofing	1	LS	$ 20,000	$ 20,000	Increased from 2028 by $5k
				Thermal and Moisture Protection Subtotal	***$ 222,800***	
Div 8	**Doors and Windows**					
	Roll-Up Doors	1	EA	$ 12,000	$ 12,000	
	Doors and Windows	1	LS	$ 25,000	$ 25,000	Increased from 2028 by $5k
				Doors and Windows Subtotal	***$ 37,000***	
Div 9	**Finishes**					
	Painting	1	LS	$ 40,000	$ 40,000	Increased from 2028 by $10k
				Finishes Subtotal	***$ 40,000***	

Div 10	**Specialties**					
	None					
				Specialties Subtotal	***$ -***	
Div 11	**Equipment**					
	ATAD System Equipment	1	LS	$ 4,440,414	$ 4,440,414	Quote from TPS
	Dewatering System Improvements	1	LS	$ 470,000	$ 470,000	Includes 3 new dewatering units, polymer system
	Thickening System Improvements	1	LS	$ 410,000	$ 410,000	Includes 3 new thickening units, TWAS pumps, polymer system upgrades
	WAS Pump	2	EA	$ 15,000	$ 30,000	Assumed one additional pump needed from 2028 to 2038
	Installation	30%	%	$ 1,605,124	$ 1,605,124	
				Equipment Subtotal	***$ 6,955,538***	
Div 13	**Special Construction**					
	Bridge Crane (Dewatering)	1	LS	$ 100,000	$ 100,000	
	Trolley and Hoist (ATAD)	1	LS	$ 25,000	$ 25,000	
				Special Construction Subtotal	***$ 125,000***	
Div 15	**Mechanical**					
	HVAC System	5,070	SF	$ 22	$ 111,540	Area of equipment/electrical room
	Plumbing	5,070	SF	$ 10	$ 50,700	Area of equipment/electrical room
	Piping & Valves	1	LS	$ 50,000	$ 50,000	Increased from 2028 by $5k
	Installation	30%	%	$ 63,672	$ 63,672	
				Mechanical Subtotal	***$ 275,912***	
				BASE CONSTRUCTION SUBTOTAL	***$ 11,953,000***	
Div 16	**Electrical and Controls**					
	Electrical and Controls	10%	%	$ 709,254	$ 709,254	TPS provides MCC, VFD, I&C equipment costs
	Instrumentation, Controls and Programming	7%	%	$ 515,792	$ 515,792	HDR provides programming
				Electrical and Instrumentation Subtotal	***$ 1,225,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 13,178,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 3,953,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 1,713,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 18,844,000***	

	Engineering Design/Construction Services	20%			$ 3,769,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 22,615,000***	
	Town Project Contingency	5%			$ 1,131,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 23,746,000**	

ANNUAL OPERATION AND MAINTENANCE COSTS						
Annual Costs - Current						
	O&M Personnel	2,920	hrs	$ 32	$ 93,440	8 hours per day
	Polymer	37	tote	$ 3,800	$ 138,700	Assumes similar polymer usage to existing system - one tote every 10 days
	Hauling Costs	756	ton	$ 240	$ 181,463	Assumes 4,143 lb/day hauled (2017 max month value)
	Total Energy Use	159	hp			Assumes 34% draw of total connected HP for 2028 system (ATAD components only - does not include dewatering equip)
	Electricity	1,038,641	kWh	$ 0.08	$ 83,091	
	Contingency	1	LS	$ 99,339	$ 99,339	20% Contingency
	Annual Cost Subtotal				**$ 596,034**	
Annual Costs - Future (2038)						
	O&M Personnel	2,920	hrs	$ 49	$ 144,395	8 hours per day, costs inflated at 2.2% per year for 20 years
	Polymer	117	tote	$ 5,872	$ 685,874	Assumes similar increase in use as increase in solids - 3.2X the 2017 usage. Costs inflated at 2.2% per year for 20 years.
	Hauling Costs	2,405	ton	$ 298	$ 717,409	Assumes max month 2038 solids, 13,176 lb/d. Costs inflated at 2.2% per year for 20 years
	Total Energy Use	231	hp			Assumes 34% draw of total connected HP for 2038 system (ATAD components only - does not include dewatering equip)
	Electricity	1,508,969	kWh	$ 0.12	$ 186,547	Costs inflated at 2.2% per year for 10 years
	Contingency	1	LS	$ 346,845	$ 346,845	20% Contingency
	Annual Cost Subtotal				**$ 2,081,069**	
O&M COSTS NPV (2.1% discount rate over 20 years)					**$ 21,592,753**	
	Calculated to year 2038					
				TOTAL COSTS (20 Year NPV)	**$ 45,338,753**	

Operation and Maintenance Cost Summary

Discount Rate= 2.1%

		Cash Flows			
Year	Year #	Series (Annual Costs)	Single (Periodic Costs)	Results from Functions	
2018	0	$ 596,034		of series=	$21,592,753
2019	1	$ 670,285			
2020	2	$ 744,537		Present worth	
2021	3	$ 818,789		of singles=	$0.00
2022	4	$ 893,041			
2023	5	$ 967,292		Present worth	
2024	6	$ 1,041,544		total=	$21,592,753
2025	7	$ 1,115,796			
2026	8	$ 1,190,048			
2027	9	$ 1,264,300			
2028	10	$ 1,338,551			
2029	11	$ 1,412,803			
2030	12	$ 1,487,055			
2031	13	$ 1,561,307			
2032	14	$ 1,635,558			
2033	15	$ 1,709,810			
2034	16	$ 1,784,062			
2035	17	$ 1,858,314			
2036	18	$ 1,932,566			
2037	19	$ 2,006,817			
2038	20	$ 2,081,069			

Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan - CleanB (2028 Condition)						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 192,196	
	Bonds and Insurance	3%	%		$ 80,611	
				General Conditions Subtotal	***$ 272,806***	
Div 2	**Sitework**					
	Site Preparation	1	LS	$ 5,000	$ 5,000	
	Excavation	130	CY	$ 10	$ 1,296	40x70 primary bldg, dig 2'
	Backfill	65	CY	$ 20	$ 1,296	40x70 primary bldg, dig 2', replace 1'
	Paving	22	SY	$ 45	$ 1,000	Reroute road
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	500	LF	$ 100	$ 50,000	
	Landscaping and Restoration	1	LS	$ 5,000	$ 5,000	
				Sitework Subtotal	***$ 68,593***	
Div 3	**Concrete**					
	BCR Unit Slab	200	CY	$ 550	$ 110,000	35 x 50 slab
				Sitework Subtotal	***$ 110,000***	
Div 4	**Masonry**					
	None					
				Masonry Subtotal	***$ -***	
Div 5	**Metals**					
	Metal building	3,600	SF	$ 45	$ 162,000	
	Misc. Metals, Grating and Platforms	1	LS	$ 25,000	$ 25,000	
				Metals Subtotal	***$ 187,000***	
Div 7	**Thermal and Moisture Protection**					
	None					
				Thermal and Moisture Protection Subtotal	***$ -***	
Div 8	**Doors and Windows**					
	Roll-Up Doors	1	EA	$ 12,000	$ 12,000	
	Doors and Windows	1	LS	$ 20,000	$ 20,000	
				Doors and Windows Subtotal	***$ 32,000***	
Div 9	**Finishes**					
	Painting	1	LS	$ 20,000	$ 20,000	
				Finishes Subtotal	***$ 20,000***	
Div 10	**Specialties**					
	None					
				Specialties Subtotal	***$ -***	

Div 11	**Equipment**					
	BCR CleanB Unit	1	LS	$ 800,000	$ 800,000	BCR Quote
	WAS Pump	1	EA	$ 15,000	$ 15,000	
	Dewatering System Improvements	1	LS	$ 370,000	$ 370,000	Includes 2 new dewatering units, polymer system
	Thickening System Improvements	1	LS	$ 275,000	$ 275,000	Includes 2 new thickening units, TWAS pumps, polymer system upgrades
	Installation	30%	%	$ 438,000	$ 438,000	
				Equipment Subtotal	***$ 1,898,000***	
Div 13	**Special Construction**					
	None					
				Special Construction Subtotal	***$ -***	
Div 15	**Mechanical**					
	HVAC System	3,600	SF	$ 22	$ 79,200	
	Plumbing	3,600	SF	$ 10	$ 36,000	
	Piping & Valves	1	LS	$ 25,000	$ 25,000	
	Installation	30%	%	$ 42,060	$ 42,060	
				Mechanical Subtotal	***$ 182,260***	
				BASE CONSTRUCTION SUBTOTAL	***$ 2,771,000***	
Div 16	**Electrical and Controls**					
	Electrical and Controls	10%	%	$ 208,026	$ 277,100	
	Instrumentation and Controls	7%	%	$ 145,618	$ 145,618	HDR provides programming
				Electrical and Instrumentation Subtotal	***$ 423,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 3,194,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 958,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 415,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 4,567,000***	
	Engineering Design/Construction Services	20%			$ 913,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 5,482,000***	
	Town Project Contingency	5%			$ 274,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 5,756,000**	

Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan - BCR Neutralizer (2028 Condition)

Division	Description	Qty	Unit	Unit Cost	Total Cost	Notes/References
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 310,059	
	Bonds and Insurance	3%	%		$ 130,998	
				General Conditions Subtotal	***$ 441,056***	
Div 2	**Sitework**					
	Site Preparation	1	LS	$ 5,000	$ 5,000	
	Dewatering	1	LS	$ -	$ -	
	Excavation	130	CY	$ 10	$ 1,296	40x70 primary bldg, dig 2'
	Backfill	65	CY	$ 20	$ 1,296	40x70 primary bldg, dig 2', replace 1'
	Paving	22	SY	$ 45	$ 1,000	Reroute road
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	500	LF	$ 100	$ 50,000	
	Landscaping and Restoration	1	LS	$ 5,000	$ 5,000	
				Sitework Subtotal	***$ 68,593***	
Div 3	**Concrete**					
	BCR Unit Slab	200	CY	$ 550	$ 110,000	35 x 50 slab
				Concrete Subtotal	***$ 110,000***	
Div 4	**Masonry**					
	None					
				Masonry Subtotal	***$ -***	
Div 5	**Metals**					
	Metal building	3,600	SF	$ 45	$ 162,000	
	Misc. Metals, Grating and Platforms	1	LS	$ 25,000	$ 25,000	
				Metals Subtotal	***$ 187,000***	
Div 7	**Thermal and Moisture Protection**					
	None					
				Thermal and Moisture Protection Subtotal	***$ -***	
Div 8	**Doors and Windows**					
	Roll-Up Doors	1	EA	$ 12,000	$ 12,000	
	Doors and Windows	1	LS	$ 15,000	$ 15,000	
				Doors and Windows Subtotal	***$ 27,000***	
Div 9	**Finishes**					
	Painting	1	LS	$ 5,000	$ 5,000	
				Finishes Subtotal	***$ 5,000***	
Div 10	**Specialties**					
	None					
				Specialties Subtotal	***$ -***	

Div 11	**Equipment**					
	BCR CleanB Unit	1	LS	$ 1,999,000	$ 1,999,000	BCR Quote
	WAS Pump	1	EA	$ 15,000	$ 15,000	
	Dewatering System Improvements	1	LS	$ 370,000	$ 370,000	Includes 2 new dewatering units, polymer system
	Thickening System Improvements	1	LS	$ 275,000	$ 275,000	Includes 2 new thickening units, TWAS pumps, polymer system upgrades
	Installation	30%	%	$ 797,700	$ 797,700	
				Equipment Subtotal	***$ 3,456,700***	
Div 13	**Special Construction**					
	None					
				Special Construction Subtotal	***$ -***	
Div 15	**Mechanical**					
	HVAC System	3,600	SF	$ 22	$ 79,200	
	Plumbing	3,600	SF	$ 10	$ 36,000	
	Piping & Valves	1	LS	$ 25,000	$ 25,000	
	Installation	30%	%	$ 42,060	$ 42,060	
				Mechanical Subtotal	***$ 182,260***	
				BASE CONSTRUCTION SUBTOTAL	***$ 4,478,000***	
Div 16	**Electrical and Controls**					
	Electrical and Controls	10%	%	$ 363,896	$ 447,800	
	Instrumentation and Controls	7%	%	$ 254,727	$ 254,727	HDR provides programming
				Electrical and Instrumentation Subtotal	***$ 703,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 5,181,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 1,554,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 674,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 7,409,000***	
	Engineering Design/Construction Services	20%			$ 1,482,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 8,893,000***	
	Town Project Contingency	5%			$ 445,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 9,338,000**	

Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan - Keep Existing (2028 Condition)						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 275,848	
	Bonds and Insurance	3%	%		$ 118,221	
				General Conditions Subtotal	***$ 394,069***	
Div 2	**Sitework**					
	Demolition and Site Preparation	1	LS	$ 10,000	$ 10,000	
	Dewatering	1	LS	$ 20,000	$ 20,000	
	Excavation	444	CY	$ 10	$ 4,444	50x80 size building, dig 3'
	Backfill	148	CY	$ 20	$ 2,963	Replace 1'
	Paving	22	SY	$ 45	$ 1,000	Estimate
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	1,000	LF	$ 100	$ 100,000	Estimate
	Landscaping and Restoration	1	LS	$ 5,000	$ 5,000	
				Sitework Subtotal	***$ 148,407***	
Div 3	**Concrete**					
	Dewatering Building Slab	222	CY	$ 750	$ 166,667	50x80 bldg, 1.5' deep slab
	Drilled Piers	800	LF	$ 350	$ 280,000	Assumes 20 piers
	Dewatering Roof	148	CY	$ 750	$ 111,111	
	Dewatering Tank Walls	385	CY	$ 850	$ 327,407	Building is 20' tall
				Concrete Subtotal	***$ 885,185***	
Div 4	**Masonry**					
	Building Exterior Veneer (8" block, insulation)	5,200	SF	$ 30	$ 156,000	
				Masonry Subtotal	***$ 156,000***	
Div 5	**Metals**					
	Misc. Metals, Grating and Platforms	1	LS	$ 20,000	$ 20,000	
				Metals Subtotal	***$ 20,000***	
Div 7	**Thermal and Moisture Protection**					
	EPDM Roofing	4,000	SF	$ 30	$ 120,000	
	Insulation	5,200	SF	$ 10	$ 52,000	
	Dampproofing	1	LS	$ 15,000	$ 15,000	
				Thermal and Moisture Protection Subtotal	***$ 187,000***	
Div 8	**Doors and Windows**					
	Roll-Up Doors	1	EA	$ 12,000	$ 12,000	
	Doors and Windows	1	LS	$ 20,000	$ 20,000	
				Doors and Windows Subtotal	***$ 32,000***	
Div 9	**Finishes**					
	Painting	1	LS	$ 15,000	$ 15,000	
				Finishes Subtotal	***$ 15,000***	
Div 10	**Specialties**					
	None					
				Specialties Subtotal	***$ -***	

Div 11	**Equipment**					
	FKC System Equipment (RST, Screw Press, WAS pump, Polymer makedown/feed system, Conveyor)	1	LS	$ 624,000	$ 624,000	High-Level Cost Estimate from FKC
	Boiler	1	LS	$ 150,000	$ 150,000	
	Transfer Pumping	1	LS	$ 20,000	$ 20,000	
	Landia Mixers	4	EA	$ 60,000	$ 240,000	
	Installation	30%	%	$ 310,200	$ 310,200	
				Equipment Subtotal	***$ 1,344,200***	
Div 13	**Special Construction**					
	Haul Liquid for 3 Months While WAS tank is down	260,000	EA	$ 1	$ 325,000	
				Special Construction Subtotal	***$ 325,000***	
Div 15	**Mechanical**					
	HVAC System	4,000	SF	$ 22	$ 88,000	Area of 50x80 building
	Plumbing	4,000	SF	$ 10	$ 40,000	Area of 50x80 building
	Piping & Valves	1	LS	$ 45,000	$ 45,000	
	Installation	30%	%	$ 51,900	$ 51,900	
				Mechanical Subtotal	***$ 224,900***	
				BASE CONSTRUCTION SUBTOTAL	***$ 3,732,000***	
Div 16	**Electrical and Controls**					
	Electrical and Controls	10%	%	$ 301,269	$ 301,269	
	Instrumentation, Controls and Programming	10%	%	$ 301,269	$ 301,269	
				Electrical and Instrumentation Subtotal	***$ 603,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 4,335,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 1,301,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 564,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 6,200,000***	
	Engineering Design/Construction Services	20%			$ 1,240,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1.00	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 7,442,000***	
	Town Project Contingency	5%			$ 372,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 7,814,000**	

ANNUAL OPERATION AND MAINTENANCE COSTS								
Annual Costs - Current								
	O&M Personnel	2,920	hrs	$	32	$	93,440	8 hours per day
	Polymer	52	tote	$	3,800	$	198,143	One tote every 7 days
	Lime	219	ton	$	258	$	56,535	Use 0.6 tons/day
	Hauling Costs	1,479	ton	$	240	$	355,043	Assumes 6,906 lb/day hauled (2017 max month value) + Lime solids
	Disposal Costs	1,479	ton	$	45	$	66,571	Assumes 6,906 lb/day disposed (2017 max month value) + Line solids
	Total Energy Use	150	hp					Estimates required HP for lime silo/system, and four Landia mixers (25HP each). Does not include dewatering system power
	Electricity	979,850	kWh	$	0.08	$	78,388	
	Contingency	1	LS	$	169,624	$	169,623.80	20% Contingency
	Annual Cost Subtotal					**$**	**1,017,743**	
Annual Costs - Future (2028)								Used **2028** for future annual costs, since 2038 annual costs would also be associated with additional capital costs, and the 20 year NPV wouldn't be accurate
	O&M Personnel	2,920	hrs	$	40	$	116,156	8 hours per day
	Polymer	104	tote	$	4,724	$	492,626	Polymer use increase proportional to solids increase = 2 times current, cost inflated at 2.2% per year for ten years
	Lime	438	ton	$	321	$	140,558	Lime increase proportional to solids increase = 2 times current, cost inflated at 2.2% per year for ten years
	Hauling Costs	3,000	ton	$	298	$	895,127	Assumes 14,040 lb/day hauled (2028 max month biosolids) + Lime solids, cost inflated at 2.2% per year for ten years
	Disposal Costs	3,000.30	ton	$	56	$	167,836	Assumes 14,040 lb/day disposed (2028 max month value) + Lime solids
	Total Energy Use	150	hp					Estimates required HP for lime silo/system, and four Landia mixers (25HP each). Does not include dewatering system power
	Electricity	979,850	kWh	$	0.10	$	97,445	
	Contingency	1	LS	$	381,950	$	381,950	20% Contingency
	Annual Cost Subtotal					**$**	**2,291,698**	
O&M COSTS NPV (2.1% discount rate over 10 years)						**$**	**15,845,339**	
	Calculated to year 2028							
					TOTAL COSTS (10 Year NPV)	**$**	**23,659,339**	

Operation and Maintenance Cost Summary

Discount Rate= 2.1%

		Cash Flows			
Year	Year #	Series (Annual Costs)	Single (Periodic Costs)	Results from Functions	
2018	0	$ 1,017,743		of series=	$15,845,339
2019	1	$ 1,145,138			
2020	2	$ 1,272,534		Present worth	
2021	3	$ 1,399,929		of singles=	$0.00
2022	4	$ 1,527,325			
2023	5	$ 1,654,721		Present worth	
2024	6	$ 1,782,116		total=	$15,845,339
2025	7	$ 1,909,512			
2026	8	$ 2,036,907			
2027	9	$ 2,164,303			
2028	10	$ 2,291,698			
2029	11				
2030	12				
2031	13				
2032	14				
2033	15				
2034	16				
2035	17				
2036	18				
2037	19				
2038	20				

Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan - Keep Existing (2038 Condition)						
Division	**Description**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Notes/References**
Div 0	**General Conditions**					
	General Conditions	7%	%		$ 699,563	
	Bonds and Insurance	3%	%		$ 299,813	
				General Conditions Subtotal	***$ 999,376***	
Div 2	**Sitework**					
	Demolition and Site Preparation	1	LS	$ 15,000	$ 15,000	Increased by $5k since 2028
	Dewatering	1	LS	$ 25,000	$ 25,000	Increased by $5k since 2028
	Excavation	1778	CY	$ 10	$ 17,778	100 ft x 160 ft size building, dig 3'. Assumes double the bldg size of 2028.
	Backfill	593	CY	$ 20	$ 11,852	Replace 1'
	Paving	22	SY	$ 45	$ 1,000	Estimate
	Sidewalk and Curb and Gutter	1	LS	$ 5,000	$ 5,000	
	Yard Piping	1,000	LF	$ 100	$ 100,000	Estimate
	Landscaping and Restoration	1	LS	$ 5,000	$ 5,000	
				Sitework Subtotal	***$ 180,630***	
Div 3	**Concrete**					
	Dewatering Building Slab	889	CY	$ 750	$ 666,667	100 ft x 160 ft bldg, 1.5' deep slab
	Drilled Piers	1600	LF	$ 350	$ 560,000	Assumes 40 piers
	Dewatering Roof	593	CY	$ 750	$ 444,444	
	Dewatering Tank Walls	770	CY	$ 850	$ 654,815	Building is 20' tall
				Concrete Subtotal	***$ 2,325,926***	
Div 4	**Masonry**					
	Building Exterior Veneer (8" block, insulation)	10,400	SF	$ 30	$ 312,000	
				Masonry Subtotal	***$ 312,000***	
Div 5	**Metals**					
	Misc. Metals, Grating and Platforms	1	LS	$ 25,000	$ 25,000	Increased by $5k since 2028
				Metals Subtotal	***$ 25,000***	
Div 7	**Thermal and Moisture Protection**					
	EPDM Roofing	16,000	SF	$ 30	$ 480,000	
	Insulation	10,400	SF	$ 10	$ 104,000	
	Dampproofing	1	LS	$ 20,000	$ 20,000	Increased by $5k since 2028
				Thermal and Moisture Protection Subtotal	***$ 604,000***	
Div 8	**Doors and Windows**					
	Roll-Up Doors	1	EA	$ 12,000	$ 12,000	
	Doors and Windows	1	LS	$ 25,000	$ 25,000	Increased by $5k since 2028
				Doors and Windows Subtotal	***$ 37,000***	
Div 9	**Finishes**					
	Painting	1	LS	$ 20,000	$ 20,000	Increased by $5k since 2028
				Finishes Subtotal	***$ 20,000***	

Div 10	**Specialties**					
	None					
				Specialties Subtotal	*$ -*	
Div 11	**Equipment**					
	FKC System Equipment (RST, Screw Press, WAS pump, Polymer makedown/feed system, Conveyor)	3	LS	$ 624,000	$ 1,872,000	High-Level Cost Estimate from FKC
	Lime Silo/Feed System	1	LS	$ 130,000	$ 130,000	WAG
	Boiler	3	LS	$ 150,000	$ 450,000	
	Transfer Pumping	1	LS	$ 40,000	$ 40,000	
	Landia Mixers	4	EA	$ 60,000	$ 240,000	
	Installation	30%	%	$ 819,600	$ 819,600	
				Equipment Subtotal	***$ 3,551,600***	
Div 13	**Special Construction**					
	Haul Liquid for 3 Months While WAS tank is down	520,000	EA	$ 1.25	$ 650,000	Doubled from 2028
				Special Construction Subtotal	***$ 650,000***	
Div 15	**Mechanical**					
	HVAC System	16,000	SF	$ 22	$ 352,000	Area of 100x160 building
	Plumbing	16,000	SF	$ 10	$ 160,000	Area of 100x160 building
	Piping & Valves	1	LS	$ 50,000	$ 50,000	Increased by $5k since 2028
	Installation	30%	%	$ 168,600	$ 168,600	
				Mechanical Subtotal	***$ 730,600***	
				BASE CONSTRUCTION SUBTOTAL	***$ 9,436,000***	
Div 16	**Electrical and Controls**					
	Electrical and Controls	10%	%	$ 778,676	$ 778,676	
	Instrumentation, Controls and Programming	10%	%	$ 778,676	$ 778,676	
				Electrical and Instrumentation Subtotal	***$ 1,557,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 10,993,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 3,298,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 1,429,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 15,720,000***	
	Engineering Design/Construction Services	20%			$ 3,144,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1.00	LS	$ 2,000	$ 2,000	Base cost
				SUBTOTAL	***$ 18,866,000***	
	Town Project Contingency	5%			$ 943,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 19,809,000**	

ANNUAL OPERATION AND MAINTENANCE COSTS						
Annual Costs - Current						
	O&M Personnel	2,920	hrs	$ 32	$ 93,440	8 hours per day
	Polymer	52	tote	$ 3,800	$ 198,143	One tote every 78 days
	Lime	219	ton	$ 258	$ 56,535	Use 0.6 tons/day
	Hauling Costs	1,479	ton	$ 240	$ 355,043	Assumes 6,906 lb/day hauled (2017 max month value) + Lime solids
	Disposal Costs	1,479	ton	$ 45	$ 66,571	Assumes 6,906 lb/day disposed (2017 max month value) + Line solids
	Total Energy Use	150	hp			Estimates required HP for lime silo/system, and four Landia mixers (25HP each). Does not include dewatering system power
	Electricity	979,850	kWh	$ 0.08	$ 78,388	
	Contingency	1	LS	$ 169,624	$ 169,623.80	20% Contingency
	Annual Cost Subtotal				**$ 1,017,743**	
Annual Costs - Future (2038)						
	O&M Personnel	2,920	hrs	$ 49	$ 144,395	8 hours per day, costs inflated at 2.2% per year for 20 years
	Polymer	167	tote	$ 5,872	$ 979,820	Polymer use increase proportional to solids increase = 3.2 times current, cost inflated at 2.2% per year for 20 years
	Lime	701	ton	$ 399	$ 279,566	Lime increase proportional to solids increase = 3.2 times current, cost inflated at 2.2% per year for 20 years
	Hauling Costs	4,709	ton	$ 371	$ 1,746,271	Assumes 21,960 lb/day hauled (2038 max month biosolids) + Lime Solids, cost inflated at 2.2% per year for 20 years
	Disposal Costs	4,709	ton	$ 56	$ 263,393	Assumes 21,960 lb/day disposed (2028 max month value) + Lime Solids
	Total Energy Use	200	hp			Estimates required HP for lime silo/systems, and four Landia mixers (25HP each). Does not include dewatering system power
	Electricity	1,306,466	kWh	$ 0.12	$ 161,513	
	Contingency	1	LS	$ 1,072,487	$ 1,072,487	30% Contingency
	Annual Cost Subtotal				**$ 4,647,444**	
O&M COSTS NPV (2.1% discount rate over 20 years)					**$ 45,382,216**	
	Calculated to year 2038					
				TOTAL COSTS (20 Year NPV)	**$ 65,191,216**	

Operation and Maintenance Cost Summary

Discount Rate= 2.1%

		Cash Flows			
Year	Year #	Series (Annual Costs)	Single (Periodic Costs)	Results from Functions	
2018	0	$ 1,017,743		of series=	$45,382,216
2019	1	$ 1,199,228			
2020	2	$ 1,380,713		Present worth	
2021	3	$ 1,562,198		of singles=	$0.00
2022	4	$ 1,743,683			
2023	5	$ 1,925,168		Present worth	
2024	6	$ 2,106,653		total=	$45,382,216
2025	7	$ 2,288,138			
2026	8	$ 2,469,623			
2027	9	$ 2,651,109			
2028	10	$ 2,832,594			
2029	11	$ 3,014,079			
2030	12	$ 3,195,564			
2031	13	$ 3,377,049			
2032	14	$ 3,558,534			
2033	15	$ 3,740,019			
2034	16	$ 3,921,504			
2035	17	$ 4,102,989			
2036	18	$ 4,284,474			
2037	19	$ 4,465,959			
2038	20	$ 4,647,444			

Appendix A: Existing Facility Improvements Cost Estimates

APPENDIX A
Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan
Dewatering Building Odor Control Improvements

Division	Description	Qty	Unit	Unit Cost	Total Cost	Notes/ References
Div 0	**General Conditions**					
	General Conditions	7%			$ 8,190	
	Bonds	3%			$ 3,510	
				General Conditions Subtotal	***$ 11,700***	
Div 11	**Equipment**					
	OC Ductwork	300	LF	$ 250	$ 75,000	Estimate
		1	LS	$ 15,000	$ 15,000	Quote from Graver
				Equipment Subtotal	***$ 90,000***	
Div 16	**Electrical and Controls**					
	Electrical	30%	%	$ 27,000	$ 27,000	
				Electrical and Controls Subtotal	***$ 27,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 128,700***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 39,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 17,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 184,700***	
	Engineering Design/Construction Services	20%			$ 37,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 1,000	$ 1,000	Base cost
				SUBTOTAL	***$ 223,000***	
	Town Project Contingency	5%			$ 11,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 234,000**	

APPENDIX A
Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan
Headworks Odor Control Improvements

Division	Description	Qty	Unit	Unit Cost	Total Cost	Notes/ References
Div 0	**General Conditions**					
	General Conditions	7%			$ 2,180	
	Bonds	3%			$ 940	
				General Conditions Subtotal	***$ 3,120***	
Div 15	**Mechanical**					
	Carbon Filter Installation	1	LS	$ 20,000	$ 20,000	
	Activated Carbon Filters	4	EA	$ 1,000	$ 4,000	
				Mechanical Subtotal	***$ 24,000***	
Div 16	**Electrical and Controls**					
	Electrical	30%	%	$ 7,200	$ 7,200	
				Electrical and Controls Subtotal	***$ 7,200***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 34,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 10,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 4,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 48,000***	
	Engineering Design/Construction Services	20%			$ 10,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 1,000	$ 1,000	Base cost
				SUBTOTAL	***$ 59,000***	
	Town Project Contingency	5%			$ 3,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 62,000**	

APPENDIX A
Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan
Dewatering Polymer Improvements

Division	Description	Qty	Unit	Unit Cost	Total Cost	Notes/ References
Div 0	**General Conditions**					
	General Conditions	7%			$ 1,358	
	Bonds	3%			$ 582	
				General Conditions Subtotal	***$ 1,940***	
Div 2	**Sitework**					
					$ -	
				Sitework Subtotal	***$ -***	
Div 3	**Concrete**					
	Designated polymer area and containment	8	CY	$ 550	$ 4,400	
				Concrete Subtotal	***$ 4,400***	
Div 11	**Equipment**					
	Piping	1	LS	$ 15,000	$ 15,000	Estimate
				Equipment Subtotal	***$ 15,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 21,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 6,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 3,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 30,000***	
	Engineering Design/Construction Services	20%			$ 6,000	25% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 1,000	$ 1,000	Base cost
				SUBTOTAL	***$ 37,000***	
	Town Project Contingency	5%			$ 2,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 39,000**	

APPENDIX A
Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan
Effluent Parshall Flume

Division	Description	Qty	Unit	Unit Cost	Total Cost	Notes/ References
Div 0	**General Conditions**					
	General Conditions	7%			$ 2,380	
	Bonds	3%			$ 1,020	
				General Conditions Subtotal	***$ 3,400***	
Div 2	**Sitework**					
	Manhole Excavation	1	LS	$ 5,000	$ 5,000	
				Sitework Subtotal	***$ 5,000***	
Div 3	**Concrete**					
	5' diameter MH	1	LS	$ 15,000	$ 15,000	
				Concrete Subtotal	***$ 15,000***	
Div 11	**Equipment**					
	12" Parshall Flume and Instrument	1	LS	$ 12,000	$ 12,000	
				Equipment Subtotal	***$ 12,000***	
Div 16	**Electrical and Controls**					
	Electrical	30%	%	$ 3,600	$ 3,600	
	Instrument programming	1	LS	$ 2,000	$ 2,000	
				Electrical and Controls Subtotal	***$ 2,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 37,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 11,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 4,800	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 53,000***	
	Engineering Design/Construction Services	20%			$ 10,600	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 1,000	$ 1,000	Base cost
				SUBTOTAL	***$ 65,000***	
	Town Project Contingency	5%			$ 3,250	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 68,000**	

APPENDIX A
Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan
Influent Flow Measurement

Division	Description	Qty	Unit	Unit Cost	Total Cost	Notes/ References
Div 0	**General Conditions**					
	General Conditions	7%			$ 2,800	
	Bonds	3%			$ 1,200	
				General Conditions Subtotal	***$ 4,000***	
Div 2						
	BUS Cable and wire	300	LF	$ 40	$ 12,000	
	Conduit for power and instrumentation installation	300	LF	$ 60	$ 18,000	Escalated cost for high density of other utilities to cross
				Sitework Subtotal	***$ 30,000***	
Div 16	**Electrical and Controls**					
	SCADA and Programming	1	LS	$ 10,000	$ 10,000.00	
				Electrical and Controls Subtotal	***$ 10,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 44,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 13,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 6,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 63,000***	
	Engineering Design/Construction Services	20%			$ 13,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 1,000	$ 1,000	Base cost
				SUBTOTAL	***$ 77,000***	
	Town Project Contingency	5%			$ 4,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 81,000**	

APPENDIX A
Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan
Non-Potable Water System Improvements

Division	Description	Qty	Unit	Unit Cost	Total Cost	Notes/ References
Div 0	**General Conditions**					
	General Conditions	7%			$ 10,060	
	Bonds	3%			$ 4,310	
				General Conditions Subtotal	***$ 14,370***	
Div 15	**Mechanical**					
	Pump Installation	1	LS	$ 5,000	$ 5,000	
	Flow meters at process points	4	EA	$ 5,000	$ 20,000	
	New NPW Pumps	2	EA	$ 45,000	$ 90,000	
				Mechanical Subtotal	***$ 115,000***	
Div 16	**Electrical and Controls**					
	Electrical	25%	%	$ 28,750	$ 28,750	
				Electrical and Controls Subtotal	***$ 28,750***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 158,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 47,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 21,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 226,000***	
	Engineering Design/Construction Services	20%			$ 45,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 1,000	$ 1,000	Base cost
				SUBTOTAL	***$ 272,000***	
	Town Project Contingency	5%			$ 14,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 286,000**	

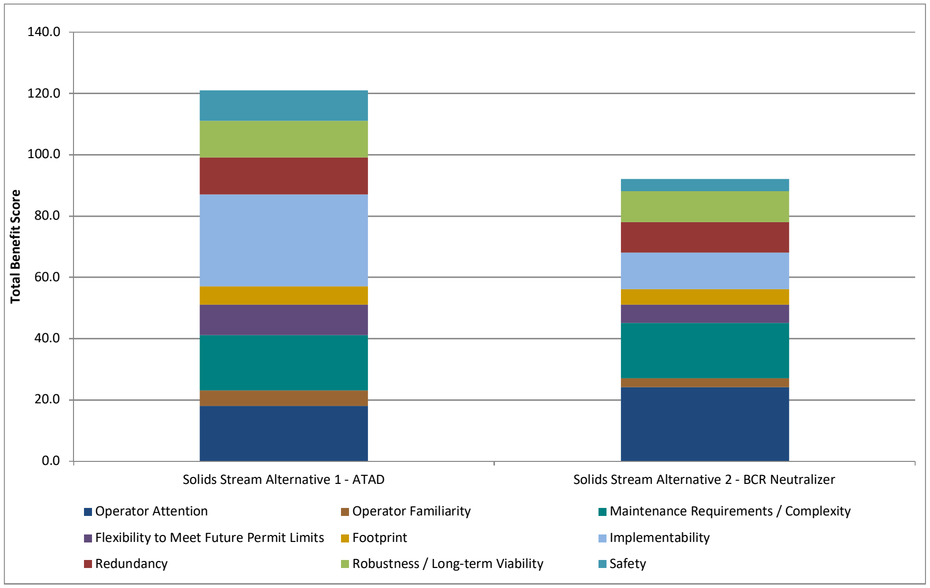
APPENDIX A
Opinion of Probable Construction Cost

Town of Erie NWRF Master Plan
Wet Well Inspection and Coating

Division	Description	Qty	Unit	Unit Cost	Total Cost	Notes/ References
Div 0	**General Conditions**					
	General Conditions	7%			$ 3,850	
	Bonds	3%			$ 1,650	
				General Conditions Subtotal	***$ 5,500***	
Div 9	**Finishes**					
	Recoating	2200	SF	$ 25	$ 55,000	
				Finishes Subtotal	***$ 55,000***	
				TOTAL DIRECT COSTS SUBTOTAL	***$ 61,000***	
	Estimating Contingency For Items Not Specifically Itemized	30%			$ 18,000	30% of Total Direct Costs
	General Contractor Overhead, Profit & Risk	10%			$ 8,000	10% of Previous Subtotal
				TOTAL ESTIMATED CONSTRUCTION COST SUBTOTAL	***$ 87,000***	
	Engineering Design/Construction Services	20%			$ 17,000	20% of Total Estimated Construction Cost Subtotal
	Permits/Feed	1	LS	$ 5,000	$ 5,000	Base cost
				SUBTOTAL	***$ 109,000***	
	Town Project Contingency	5%			$ 5,000	5% of Subtotal
				TOTAL ANTICIPATED PROJECT COST (TAPC)	**$ 114,000**	

Appendix B: Non-Economic Evaluation

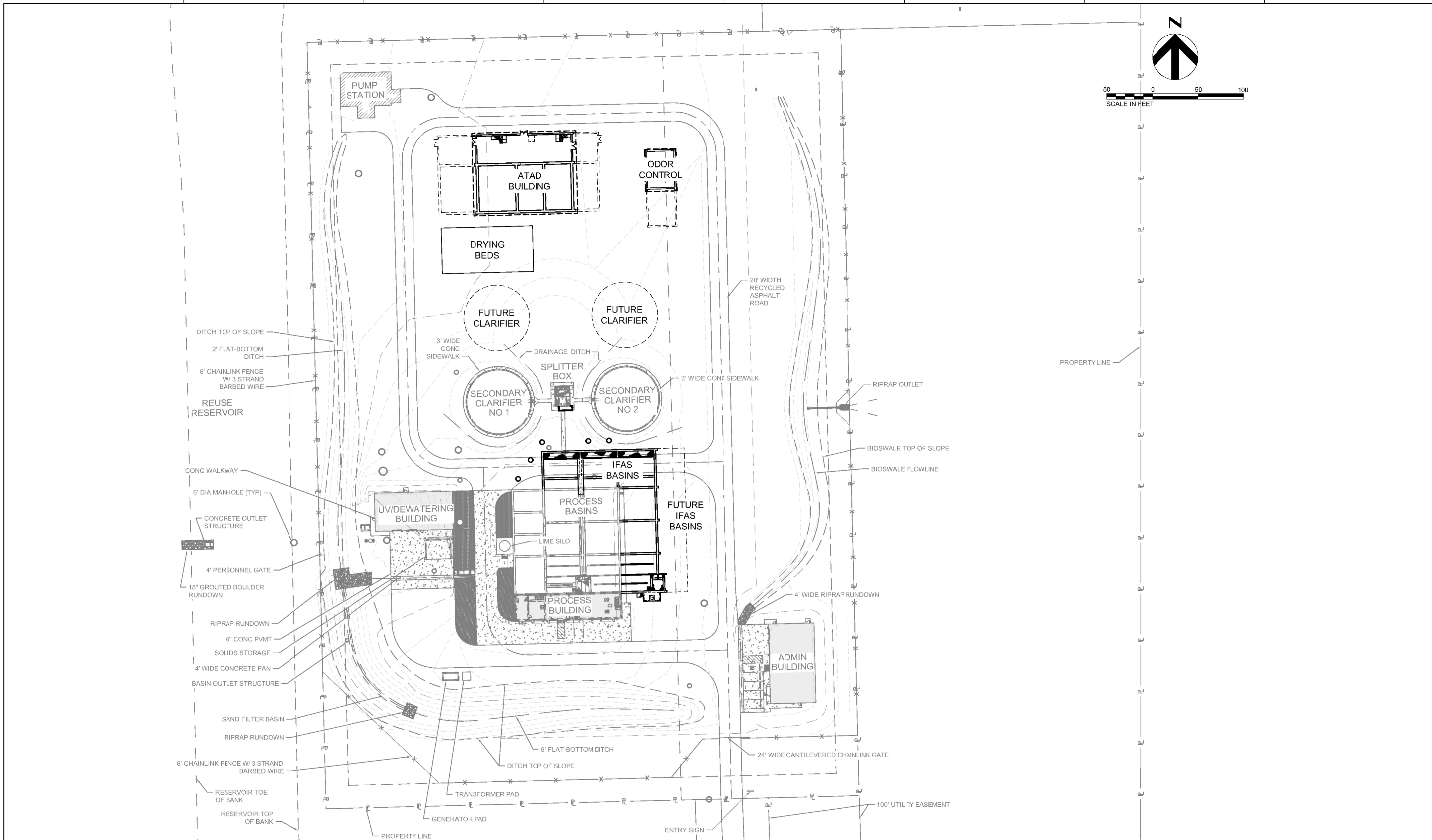
Alternatives		Score								
		Operator Attention	Operator Familiarity	Maintenance Requirements / Complexity	Flexibility to Meet Future Permit Limits	Footprint	Implementability	Redundancy	Robustness / Long-term Viability	Safety
Solids Stream Alternative 1 - ATAD		18	5	18	10	6	30	12	12	10
Solids Stream Alternative 2 - BCR Neutralizer		24	3	18	6	5	12	10	10	4



Non-Economic Criterion	Benefits or Attributes	Criteria Weighting Factor	ALT 1 - ATAD		ALT 2 - CleanB		ALT 3 - Neutralizer	
			Score	Total	Score	Total	Score	Total
Operator Attention	· Technology is self-sufficient	3	3	9	4	12	4	12
	· Low operator need to check the equipment		3	9	4	12	4	12
	Overall Criterion Score		**18**		**24**		**24**	
Operator Familiarity	· How familiar is the staff with the technology	1	2	2	1	1	1	1
	· How comfortable is the staff with operation of this technology		3	3	1	1	1	1
	· How comfortable is the staff with operating the equipment unattended, over night		2	2	3	3	2	2
	Overall Criterion Score		**5**		**4**		**3**	
Maintenance Requirements/Complexity	· How often the equipment has to be maintained	2	3	6	4	8	3	6
	· How difficult is it to maintain		2	4	3	6	3	6
	· How much downtime will the unit need to be maintain on a yearly basis		4	8	4	8	3	6
	Overall Criterion Score		**18**		**22**		**18**	
Flexibility to Meet Future Flows/Loads Needs	· Equipped to Handle Expansion?	2	5	10	3	6	3	6
	Overall Criterion Score		**10**		**6**		**6**	
Footprint	· Operational space for O&M	1	3	3	3	3	2	2
	· Space required		3	3	4	4	3	3
	Overall Criterion Score		**6**		**7**		**5**	
Implementability	· Permits and approvals are obtainable	3	5	15	2	6	1	3
	· Can implement project within the required timeframe		5	15	3	9	3	9
	Overall Criterion Score		**30**		**15**		**12**	
Redundancy	· Redundant equipment required	2	3	6	2	4	3	6
	· Feasibility in taking a piece of equipment offline		3	6	2	4	2	4
	Overall Criterion Score		**12**		**8**		**10**	
Robustness/Long-Term Viability	· How well does system operate over a wide variety of conditions	2	4	8	3	6	2	4
	· Has the ability to remain cost effective if energy and/or labor costs change significantly		2	4	3	6	3	6
	Overall Criterion Score		**12**		**12**		**10**	
Safety	· Safety of operations staff when near process or equipment	3	5	10	2	4	2	4
	Overall Criterion Score		**10**		**4**		**4**	
		Total Score	**121**		**102**		**92**	

Criteria Weighting Factor: (3 to 1) 3=Most Important 1=Least Important
Score: (5 to 1) 5=Most Favorable, 1=Least Favorable

Appendix C: Drawings



c:\pwworking\central01\d1010478\02C101.dwg, Plot, 2/1/2019 8:32:13 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

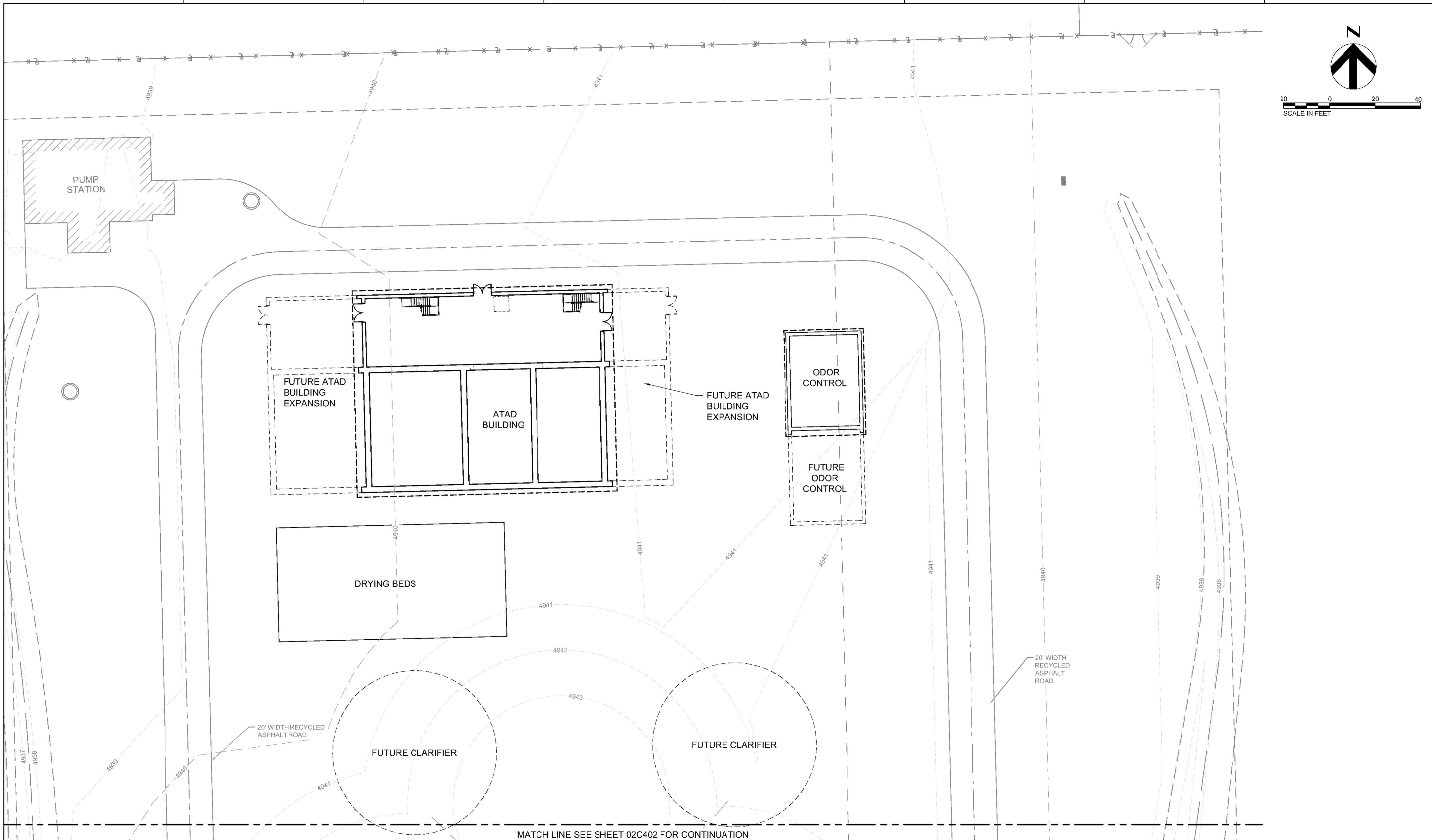
TOWN OF ERIE, CO
NRWF IMPROVEMENTS

SITE WORK
OVERALL SITE PLAN

0 1" 2"

FILENAME 02C101.dwg
SCALE AS NOTED

SHEET
02C101



c:\pwworking\central01\d1010478\02C401.dwg, Plot, 2/1/2019 8:32:26 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

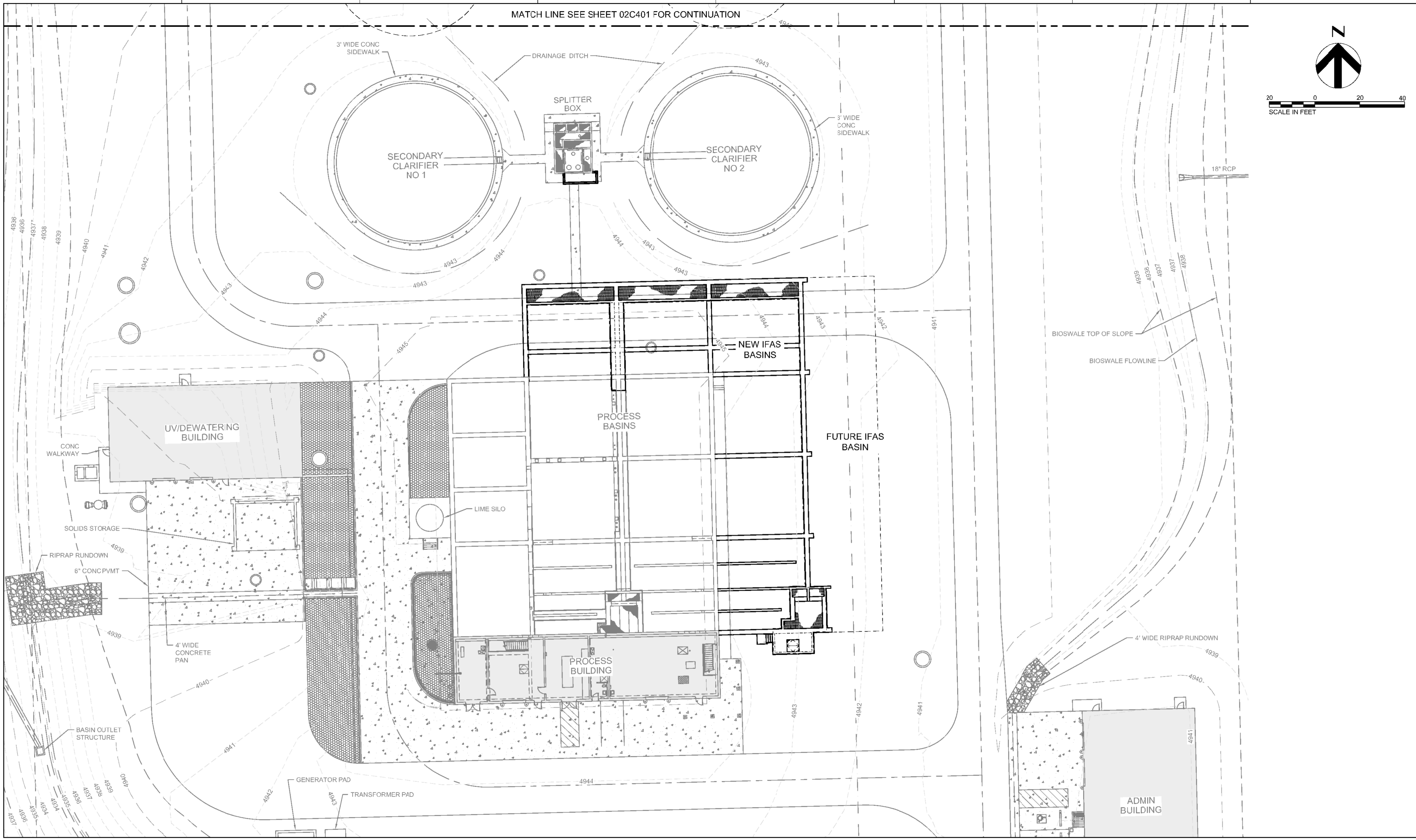
TOWN OF ERIE, CO
NRWF IMPROVEMENTS

SITE WORK
SITE GRADING PLAN - NORTH

0 1" 2"

FILENAME	02C401.dwg
SCALE	AS NOTED

SHEET
02C401



c:\pwworking\central01\d1010478\02C402.dwg, Plot, 2/1/2019 8:32:39 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

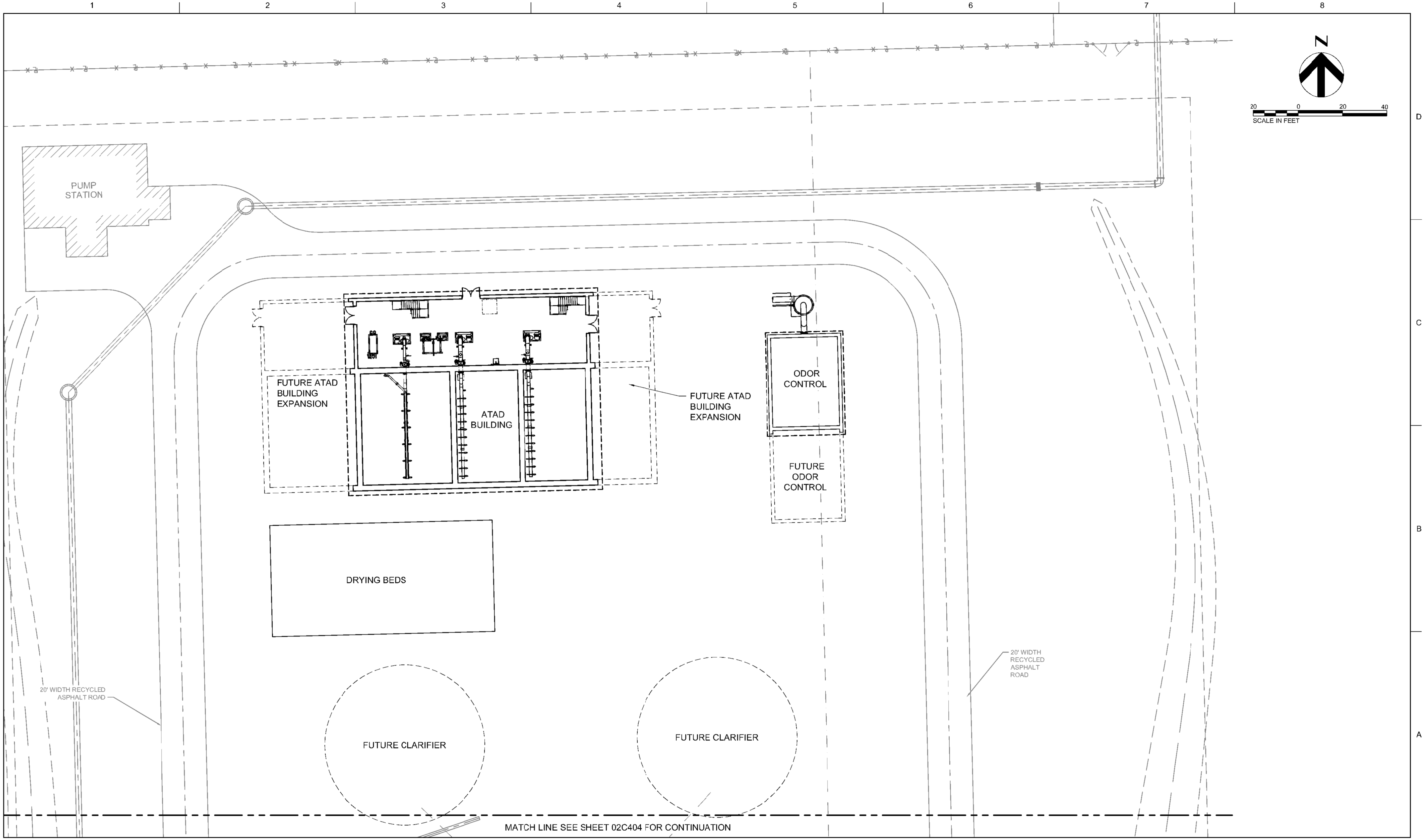
TOWN OF ERIE, CO
NRWF IMPROVEMENTS

SITE WORK
SITE GRADING PLAN - SOUTH

0 1" 2"

FILENAME	02C402.dwg
SCALE	AS NOTED

SHEET
02C402



c:\pwworking\central01\d1010478\02C403.dwg, Plot, 2/1/2019 8:32:48 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

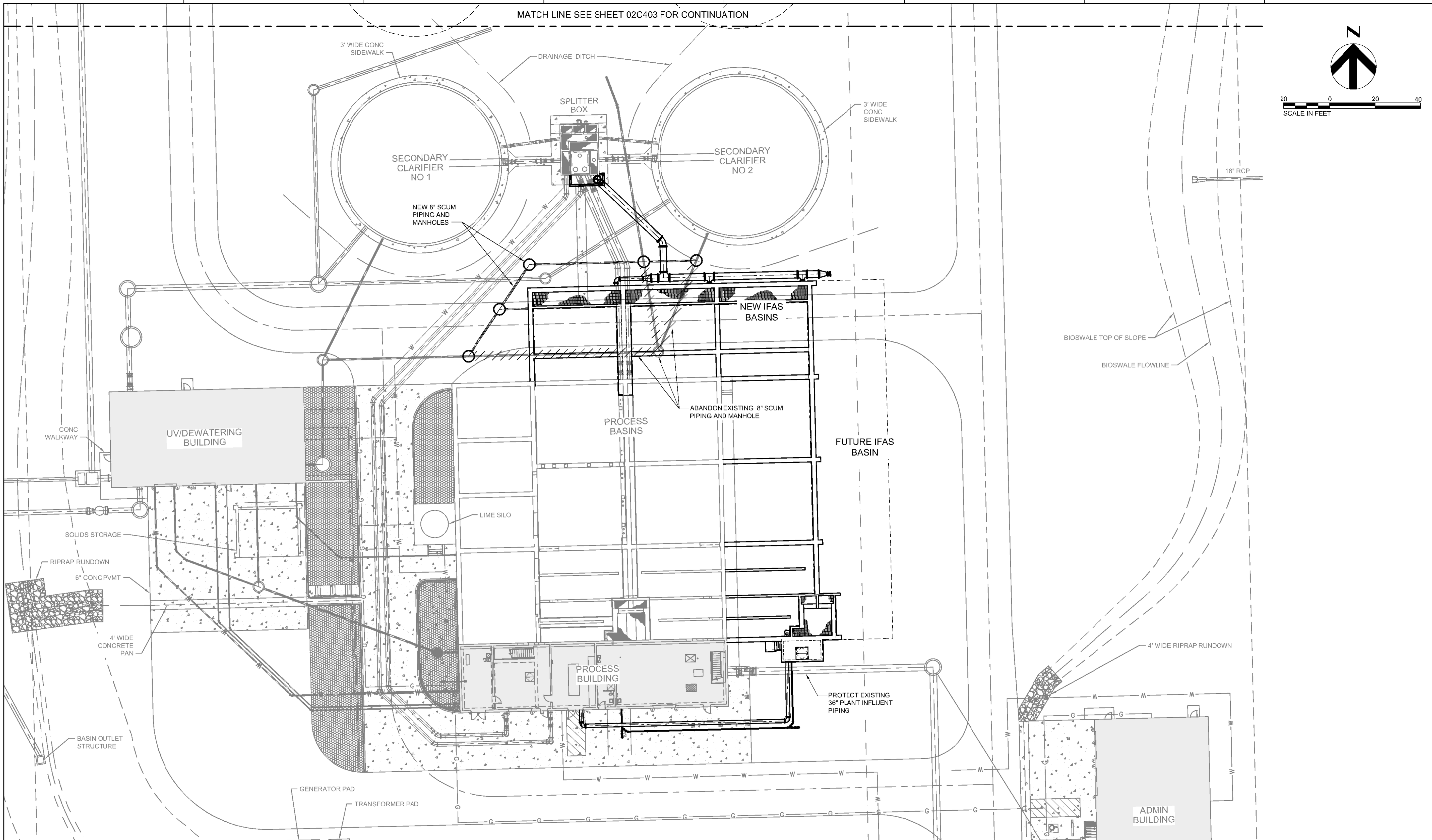
TOWN OF ERIE, CO
NRWF IMPROVEMENTS

SITE WORK
SITE PIPING PLAN - NORTH

0 1" 2"

FILENAME	02C403.dwg
SCALE	AS NOTED

SHEET
02C403



c:\pwworking\central01\d1010478\02C404.dwg, Plot, 2/1/2019 8:32:58 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

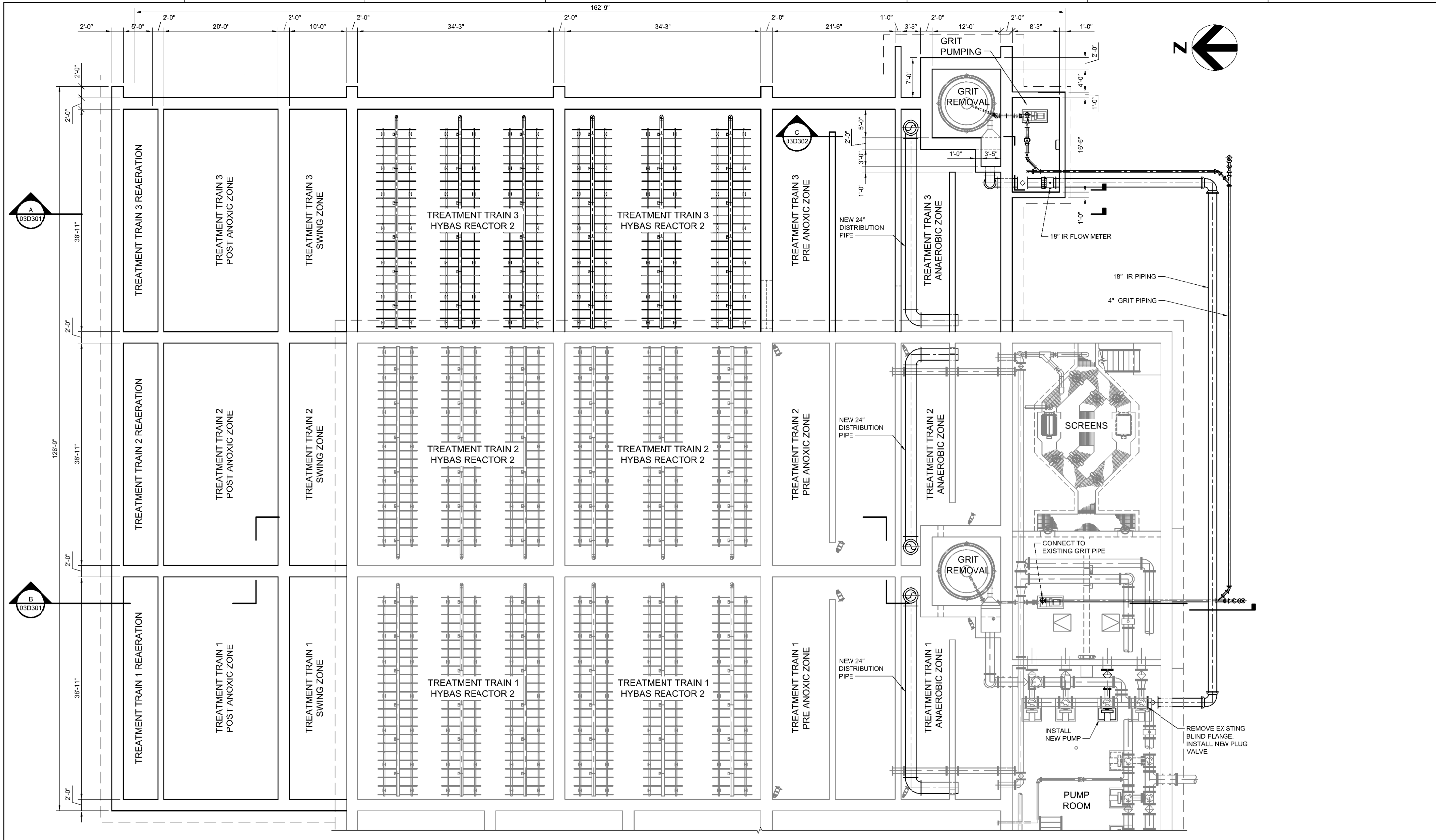
TOWN OF ERIE, CO
NRWF IMPROVEMENTS

SITE WORK
SITE PIPING PLAN - SOUTH

0 1" 2"

FILENAME 02C404.dwg
SCALE AS NOTED

SHEET
02C404



c:\pwworking\central01\d1010478\03D101.dwg, Plot, 2/1/2019 8:33:05 AM, KBREWSTE

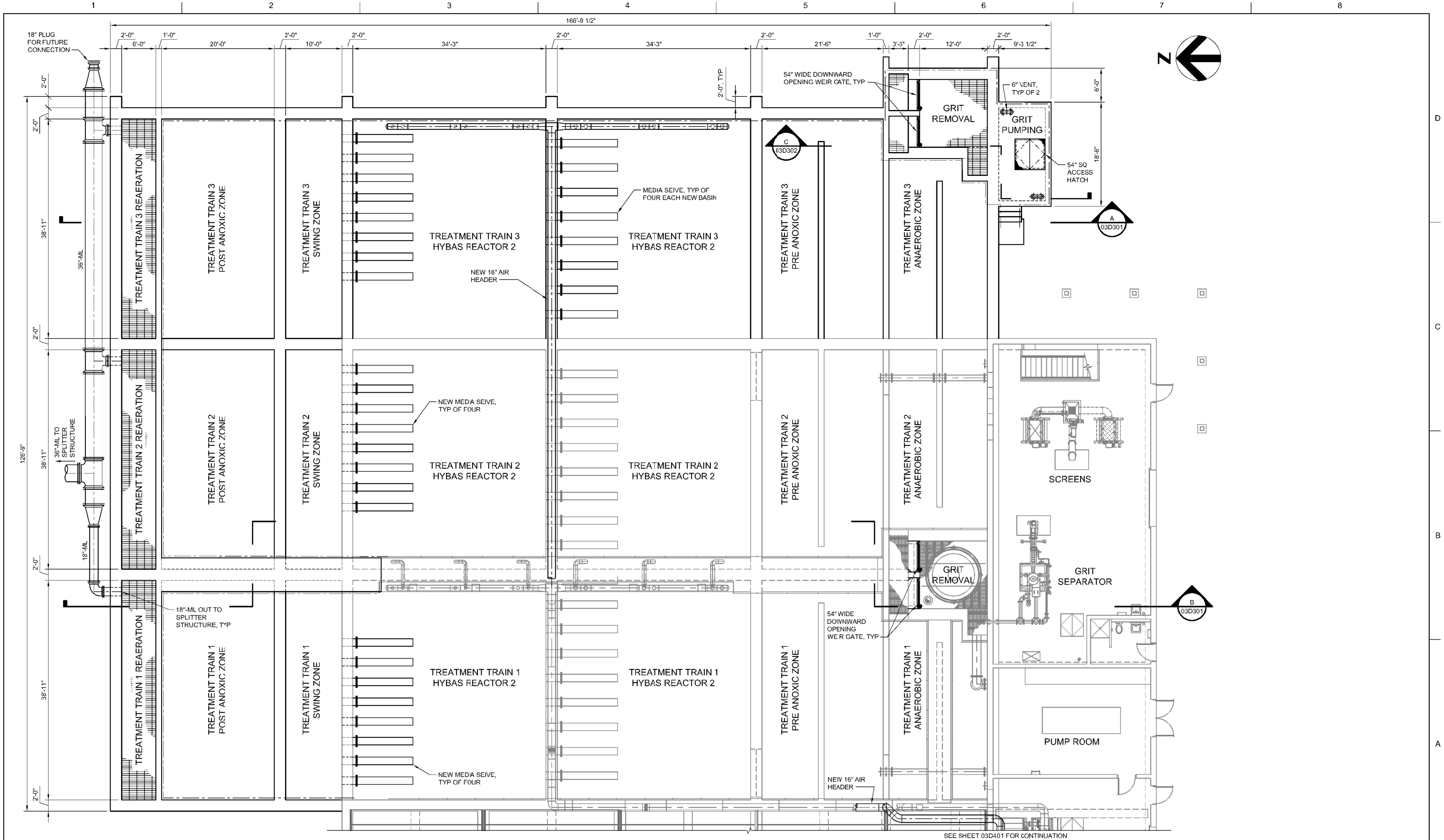
PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

ISSUE DATE DESCRIPTION

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

TREATMENT BUILDING AND BASINS LOWER LEVEL PLAN

FILENAME 03D101.dwg
SCALE 1/8" = 1'-0"
SHEET 03D101



c:\pwworking\central01\d1010478\03D102.dwg, Plot, 2/1/2019 8:33:11 AM, KBREWSTE

HDR

PROJECT MANAGER	ADAM S PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

ISSUE DATE DESCRIPTION

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

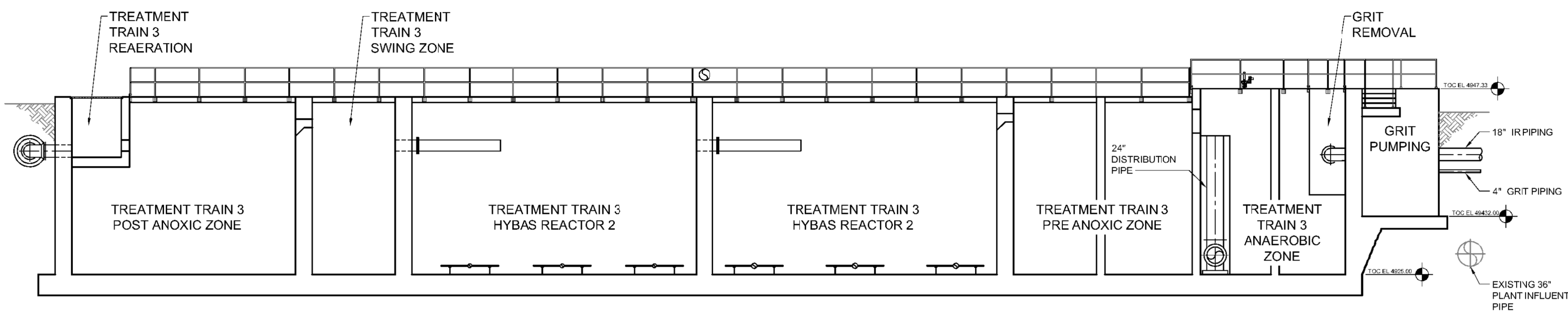
TREATMENT BUILDING AND BASINS UPPER LEVEL PLAN

0 1" 2"

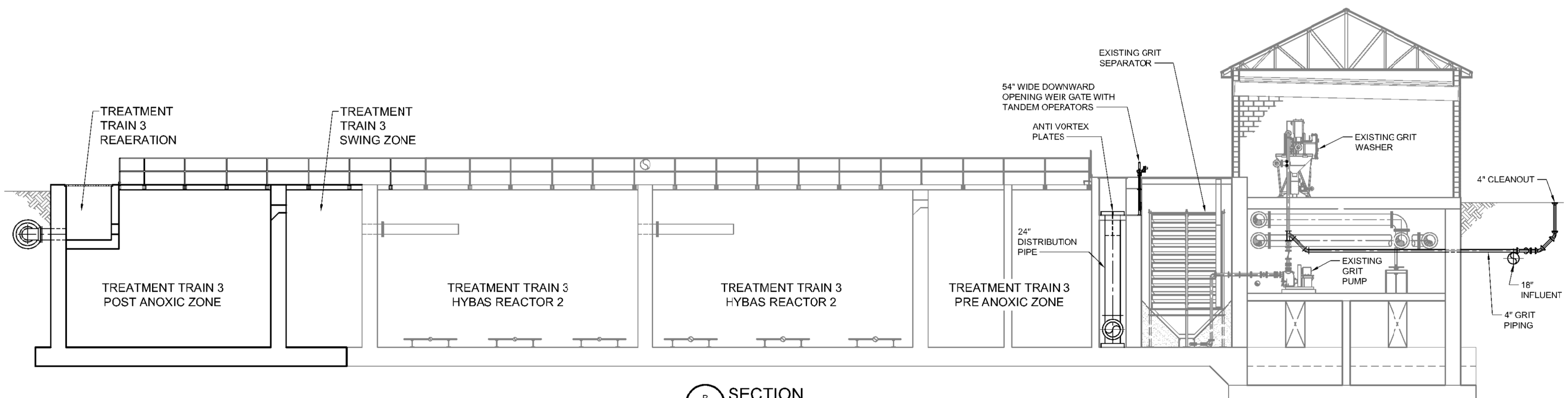
FILENAME 03D102.dwg

SCALE 1/8" = 1'-0"

SHEET **03D102**



A 03C101 SECTION
SCALE: 1/8" = 1'-0"



B 03C101 SECTION
SCALE: 1/8" = 1'-0"

c:\pwworking\central01\d1010478\03D301.dwg, Plot, 2/1/2019 8:33:18 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

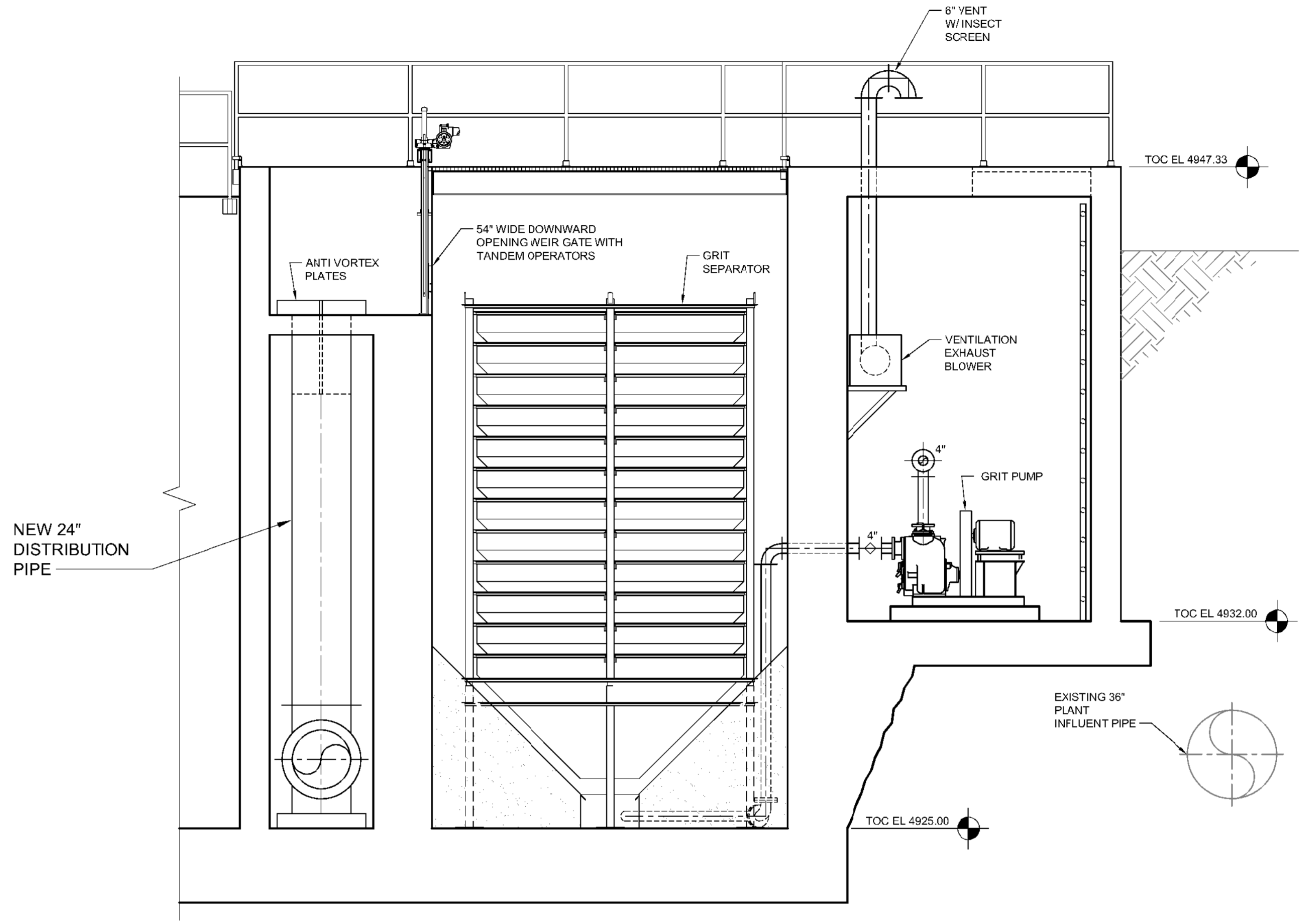
TOWN OF ERIE, CO
NRWF IMPROVEMENTS

TREATMENT BUILDING AND BASINS SECTIONS

0 1" 2"

FILENAME	03D301.dwg
SCALE	1/8" = 1'-0"

SHEET
03D301



C
03C101
SECTION
SCALE: 3/8" = 1'-0"

c:\pwworking\central01\d1010478\03D302.dwg, Plot, 2/1/2019 8:33:24 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

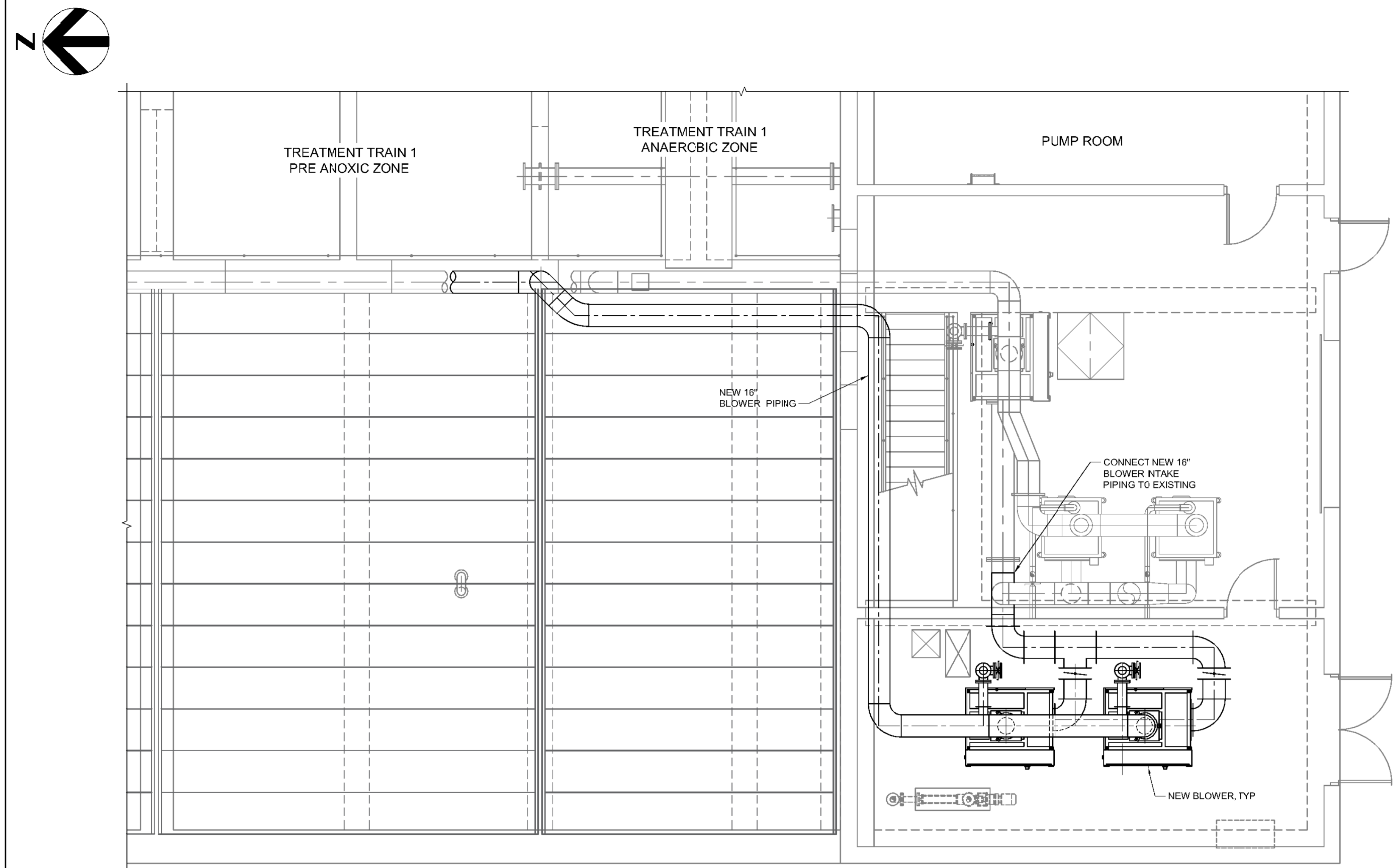
TOWN OF ERIE, CO
NRWF IMPROVEMENTS

TREATMENT BUILDING AND BASINS
SECTIONS

0 1" 2"

FILENAME 03D302.dwg
SCALE AS NOTED

SHEET
03D302



BLOWER ROOM PLAN

SCALE: 1/4" = 1'-0"

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

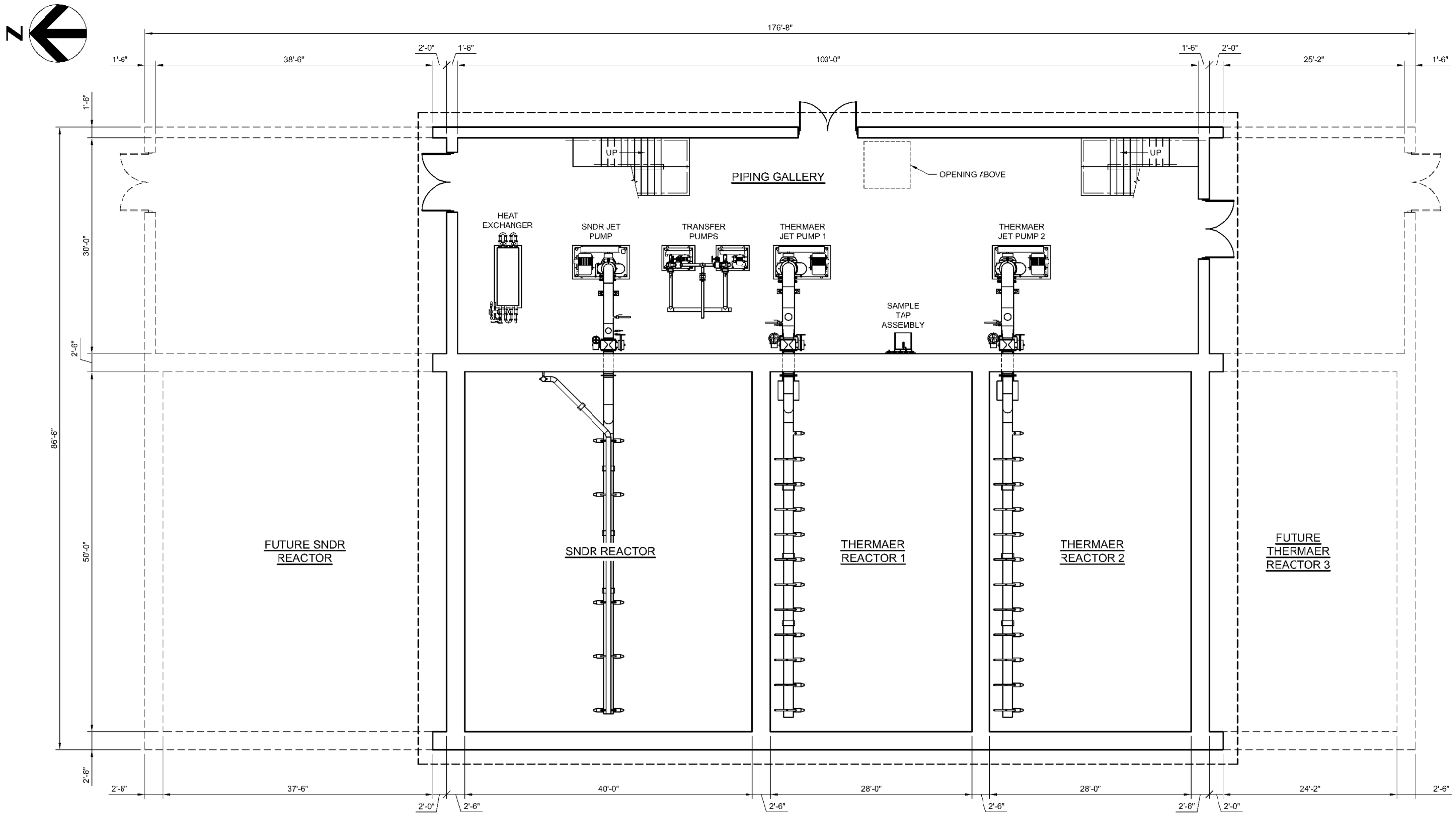
TREATMENT BUILDING AND BASINS SECTIONS

0 1" 2"

FILENAME 03D401.dwg

SCALE AS NOTED

SHEET **03D401**



GROUND LEVEL PLAN

SCALE: 1/8" = 1'-0"

c:\pwworking\central01\d1010478\04D101.dwg, Plot, 2/1/2019 8:33:37 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

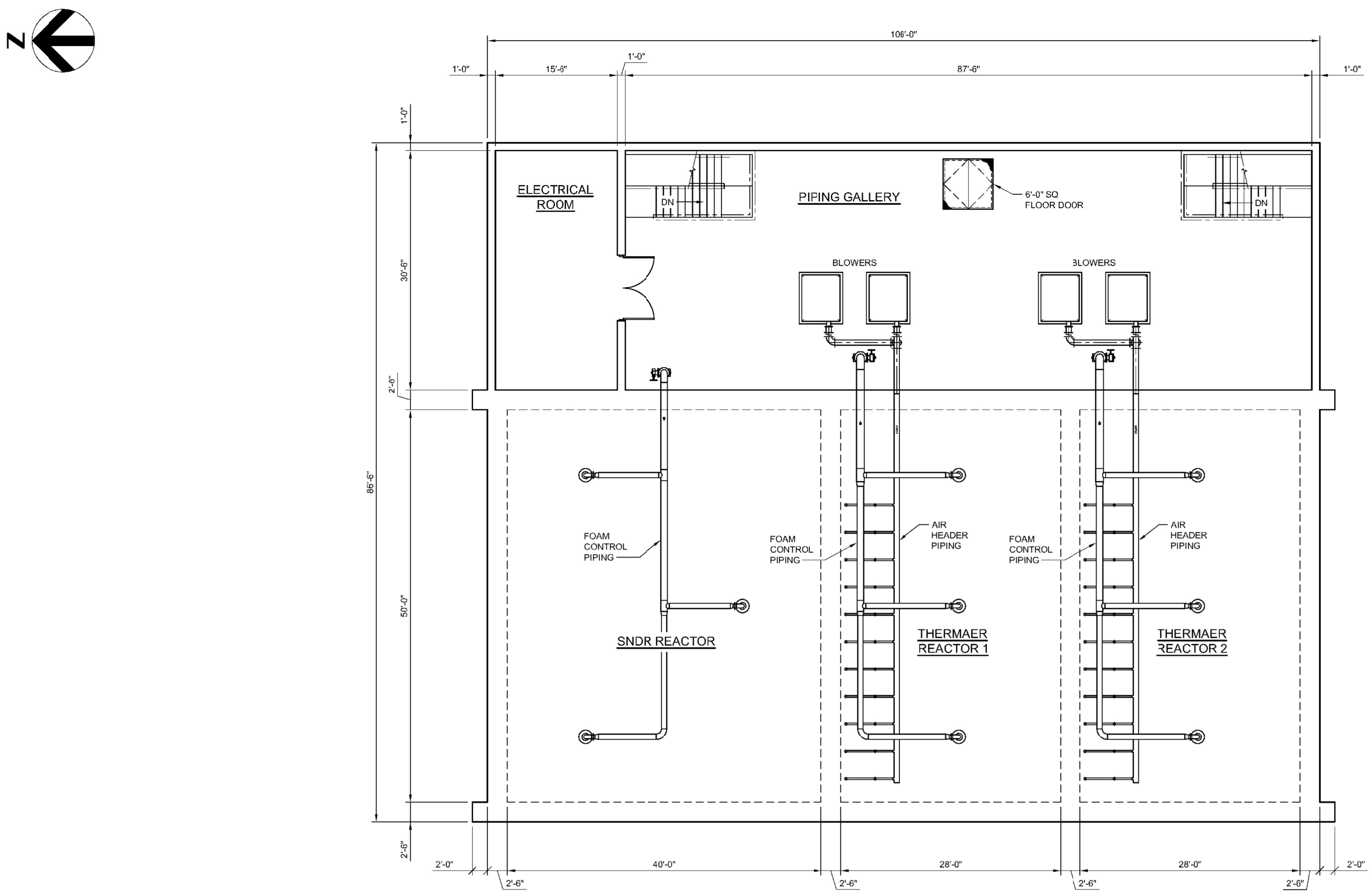
TOWN OF ERIE, CO
NRWF IMPROVEMENTS

ATAD BUILDING
GROUND LEVEL PLAN

0 1" 2"

FILENAME 04D101.dwg
SCALE AS NOTED

SHEET
04D101



UPPER LEVEL PLAN

SCALE: 1/8" = 1'-0"

c:\pwworking\central01\d1010478\04D102.dwg, Plot, 2/1/2019 8:33:43 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

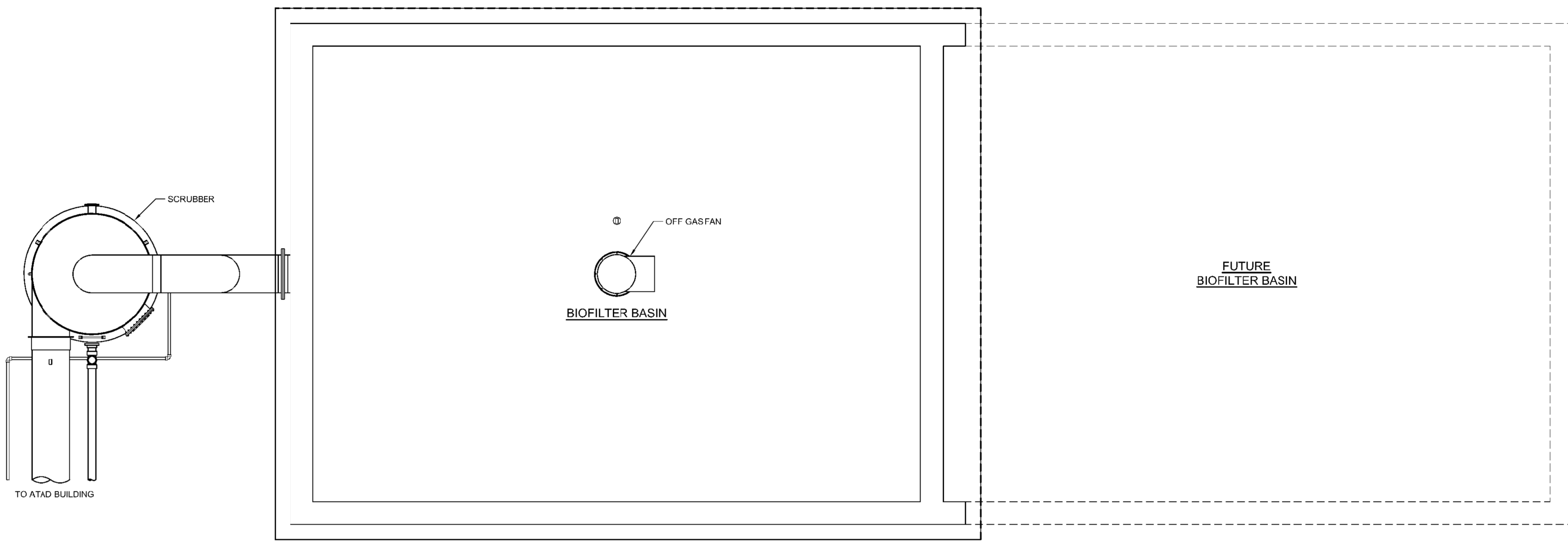
ATAD BUILDING
UPPER LEVEL PLAN

0 1" 2"

FILENAME 04D102.dwg

SCALE AS NOTED

SHEET **04D102**



GROUND LEVEL PLAN

SCALE: 1/4" = 1'-0"

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

ISSUE	DATE	DESCRIPTION

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

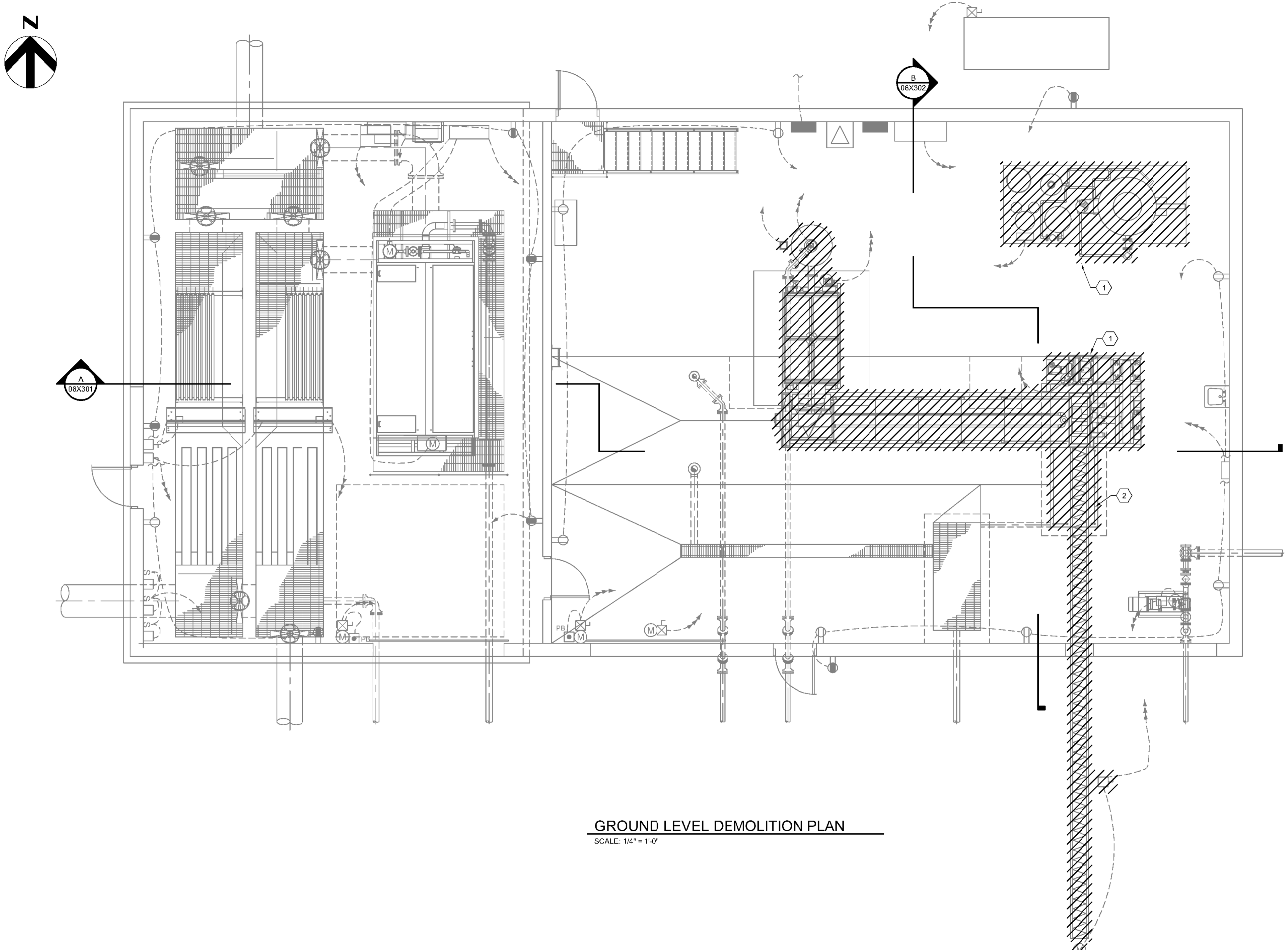
ODOR CONTROL STRUCTURE
GROUND LEVEL PLAN

0 1" 2"

FILENAME 05D101.dwg

SCALE AS NOTED

SHEET 05D101



GROUND LEVEL DEMOLITION PLAN

SCALE: 1/4" = 1'-0"

GENERAL NOTES:

A. ALL EXISTING EQUIPMENT PADS SUPPORTING REMOVED EQUIPMENT SHALL BE DEMOLISHED AND/OR GROUND BACK FLUSH TO EXISTING FLOOR.

KEY NOTES:

1. REMOVE EXISTING EQUIPMENT, TO INCLUDE ALL ELECTRICAL CONTROLS AND CONDUIT BACK TO CONTROL PANELS
2. REMOVE EXISTING GUARDRAILS.

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

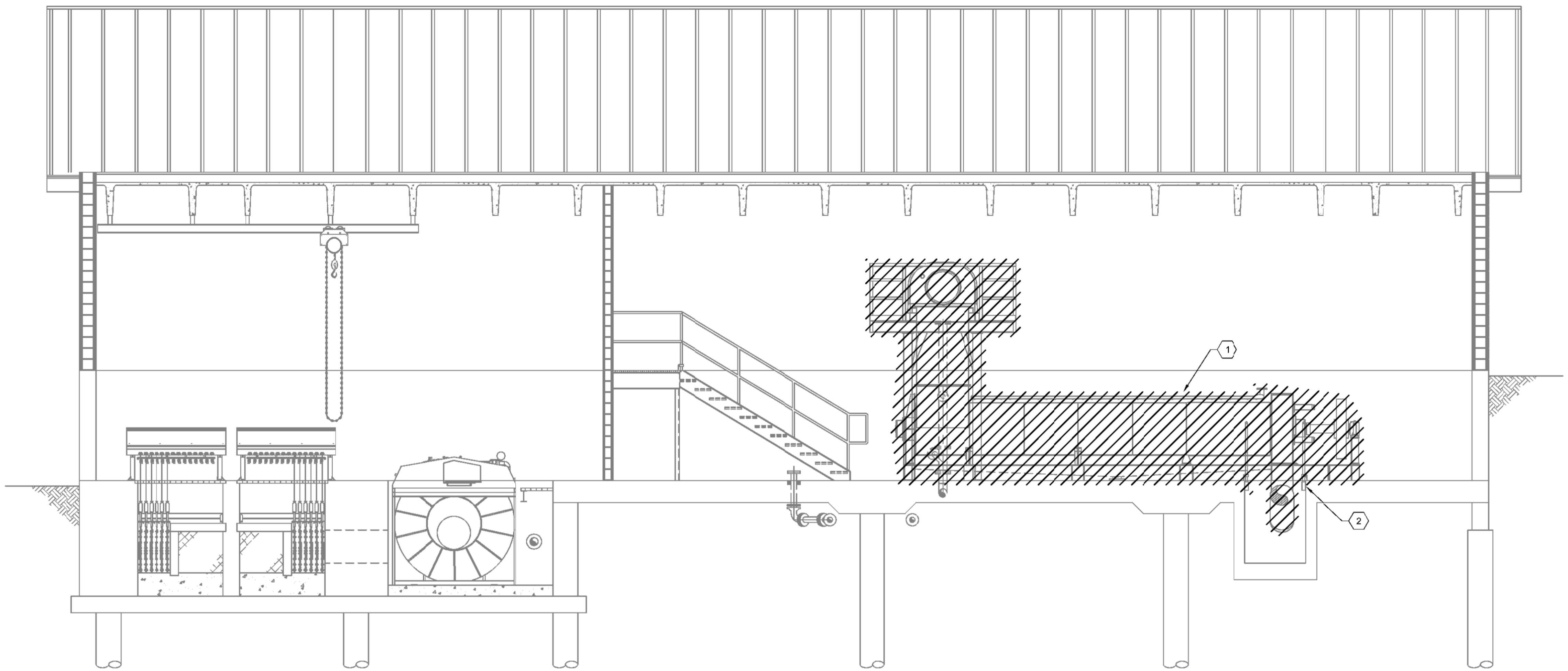
UV/DEWATERING BUILDING
GROUND LEVEL DEMOLITION PLAN

0 1" 2"

FILENAME 06X101.dwg

SCALE AS NOTED

SHEET **06X101**



A
06X101
DEMOLITION SECTION
SCALE: 1/4" = 1'-0"

GENERAL NOTES:

A. ALL EXISTING EQUIPMENT PADS SUPPORTING REMOVED EQUIPMENT SHALL BE DEMOLISHED AND/OR GROUND BACK FLUSH TO EXISTING FLOOR.

KEY NOTES:

1. REMOVE EXISTING EQUIPMENT, TO INCLUDE ALL ELECTRICAL CONTROLS AND CONDUIT BACK TO CONTROL PANELS
2. REMOVE EXISTING GUARDRAILS.

c:\pwworking\central01\d1010478\06X301.dwg, Plot, 2/1/2019 8:34:02 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

UV/DEWATERING BUILDING
DEWATERING SECTION

0 1" 2"

FILENAME 06X301.dwg
SCALE AS NOTED

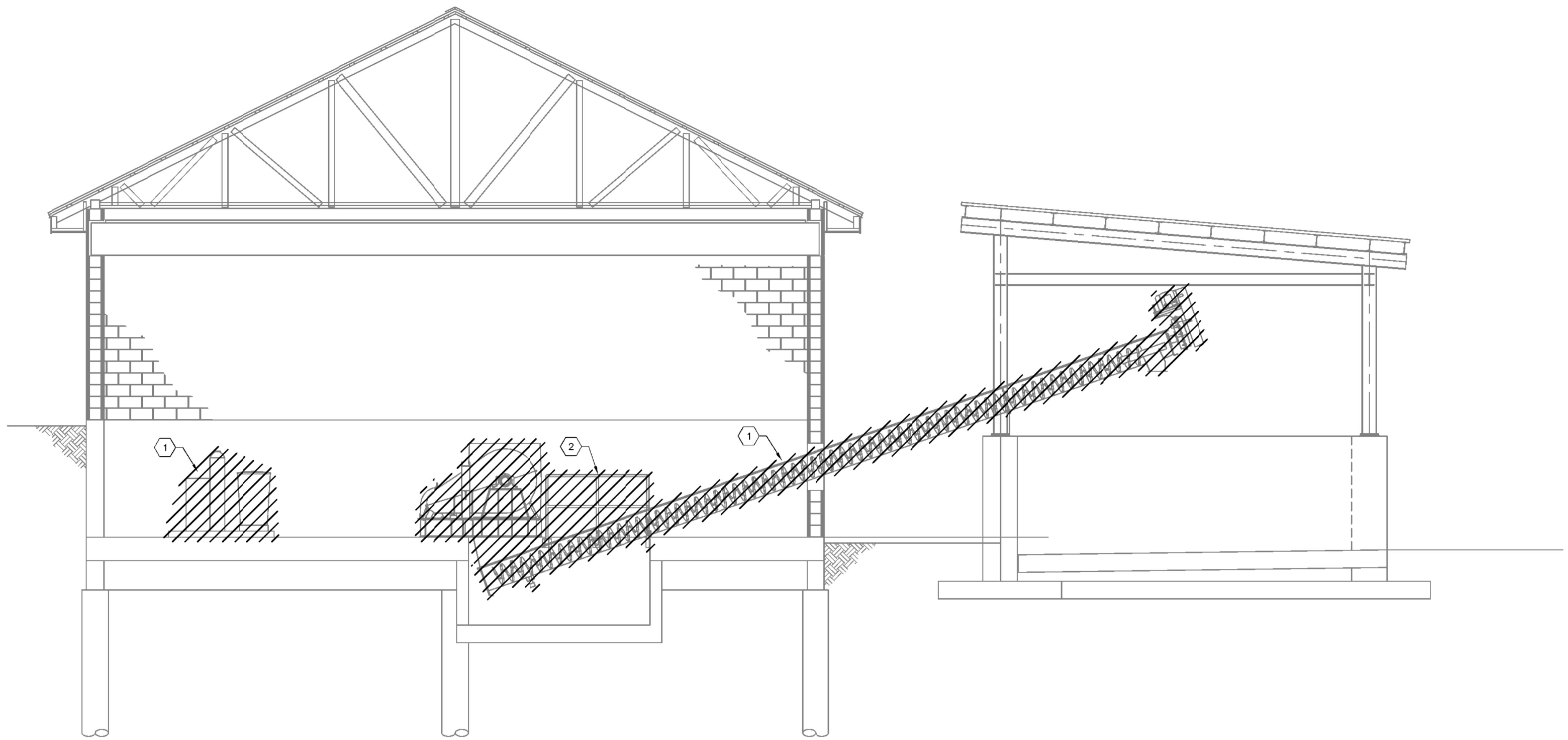
SHEET
06X301

GENERAL NOTES:

A. ALL EXISTING EQUIPMENT PADS SUPPORTING REMOVED EQUIPMENT SHALL BE DEMOLISHED AND/OR GROUND BACK FLUSH TO EXISTING FLOOR.

KEY NOTES:

1. REMOVE EXISTING EQUIPMENT, TO INCLUDE ALL ELECTRICAL CONTROLS AND CONDUIT BACK TO CONTROL PANELS
2. REMOVE EXISTING GUARDRAILS.



B / 06X101 DEMOLITION SECTION

SCALE: 1/4" = 1'-0"

HDR

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

ISSUE	DATE	DESCRIPTION

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

UV/DEWATERING BUILDING
DEWATERING SECTION

0 1" 2"

FILENAME 06X302.dwg

SCALE AS NOTED

SHEET 06X302

1 2 3 4 5 6 7 8

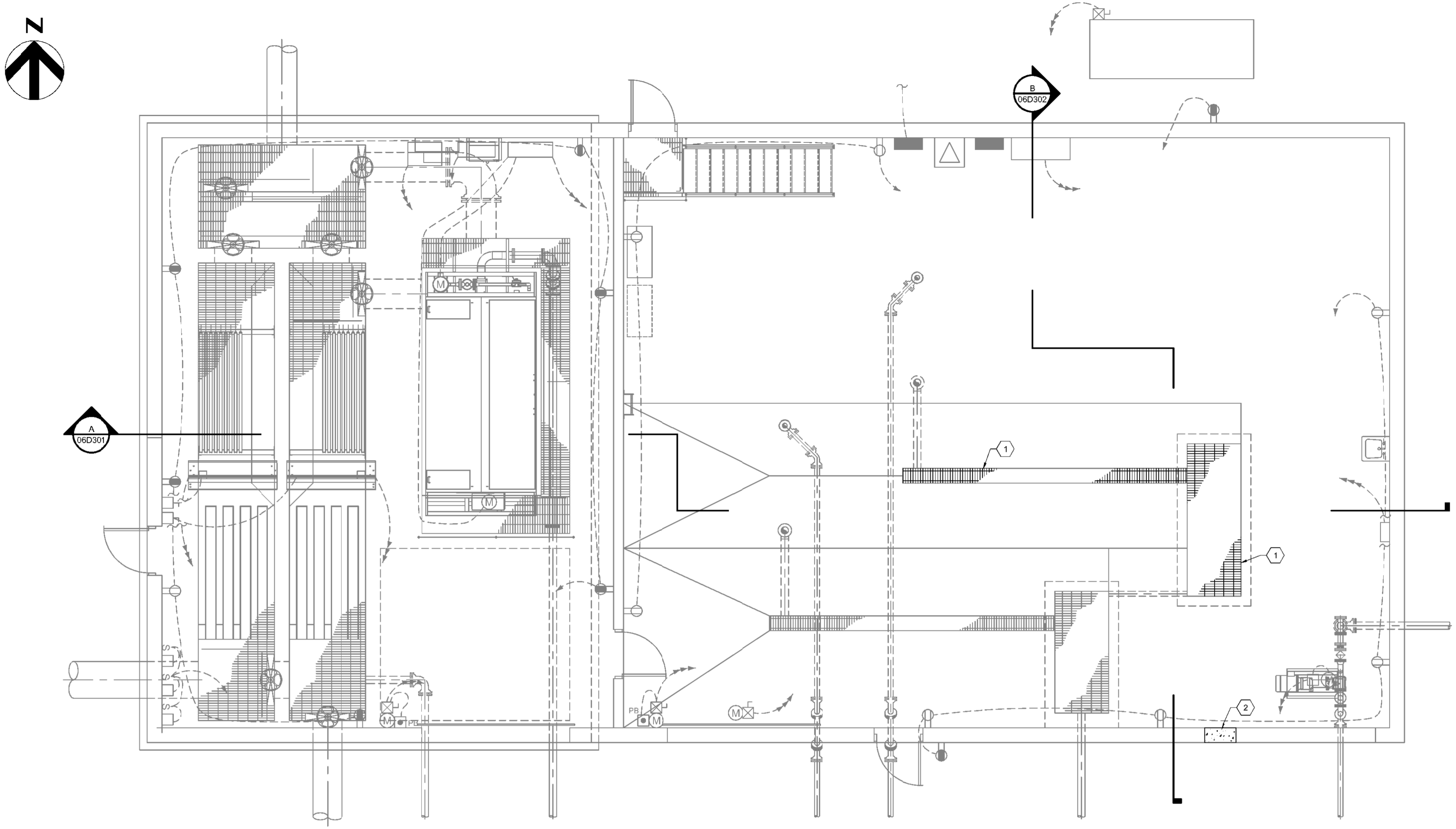
D C B A

GENERAL NOTES:

A.

KEY NOTES:

1. INSTALL NEW GRATING OVER EXISTING OPENINGS.
2. FILL EXISTING WALL OPENING, SEE DETAIL X/XXXXXX.



GROUND LEVEL PLAN

SCALE: 1/4" = 1'-0"

c:\pwworking\central01\d1010478\06D101.dwg, Plot, 2/1/2019 8:34:16 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

UV/DEWATERING BUILDING
GROUND LEVEL PLAN

0 1" 2"

FILENAME 06D101.dwg

SCALE AS NOTED

SHEET 06D101

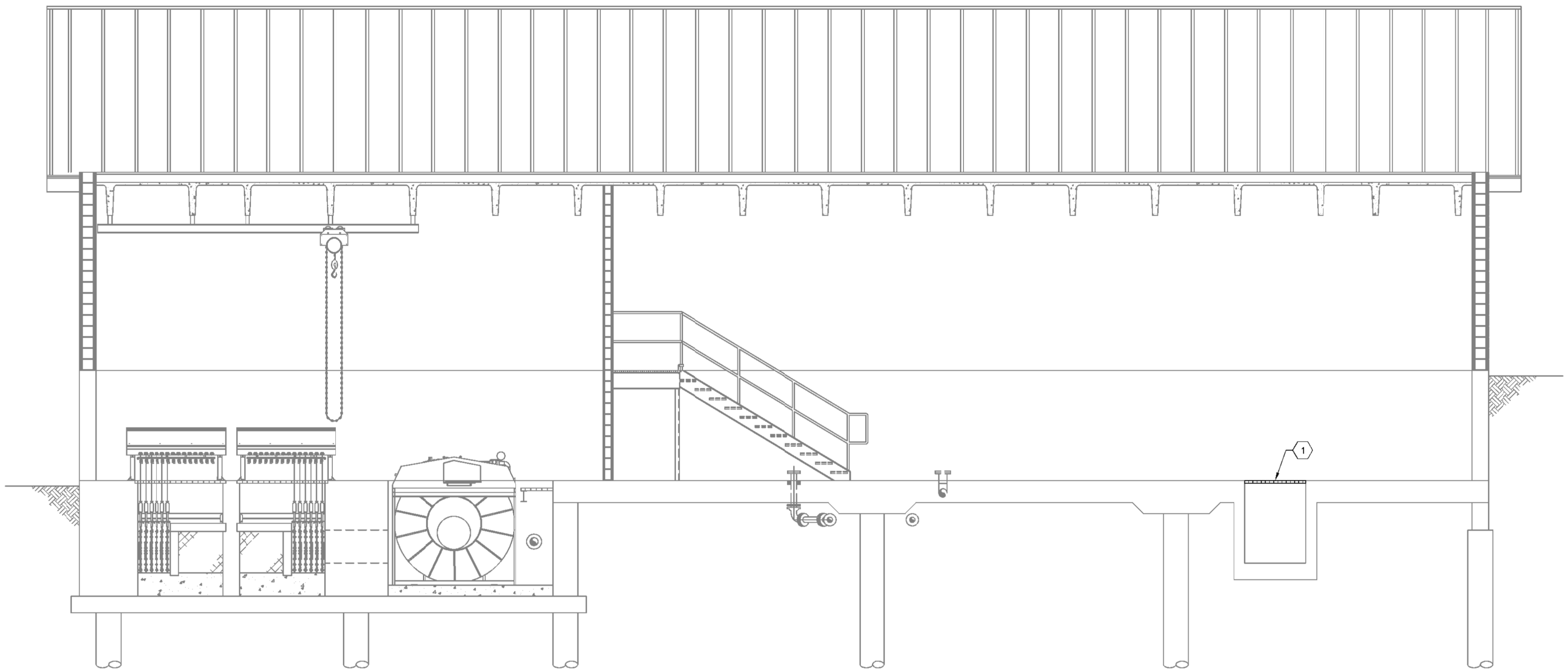
1 2 3 4 5 6 7 8

GENERAL NOTES:

A.

KEY NOTES:

1 INSTALL NEW GRATING OVER EXISTING OPENING.



A
06D101
SECTION
SCALE: 1/4" = 1'-0"

D C B A

c:\pwworking\central01\d1010478\06D301.dwg, Plot, 2/1/2019 8:34:26 AM, KBREWSTE

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

UV/DEWATERING BUILDING
SECTION

0 1" 2"

FILENAME 06D301.dwg
SCALE AS NOTED

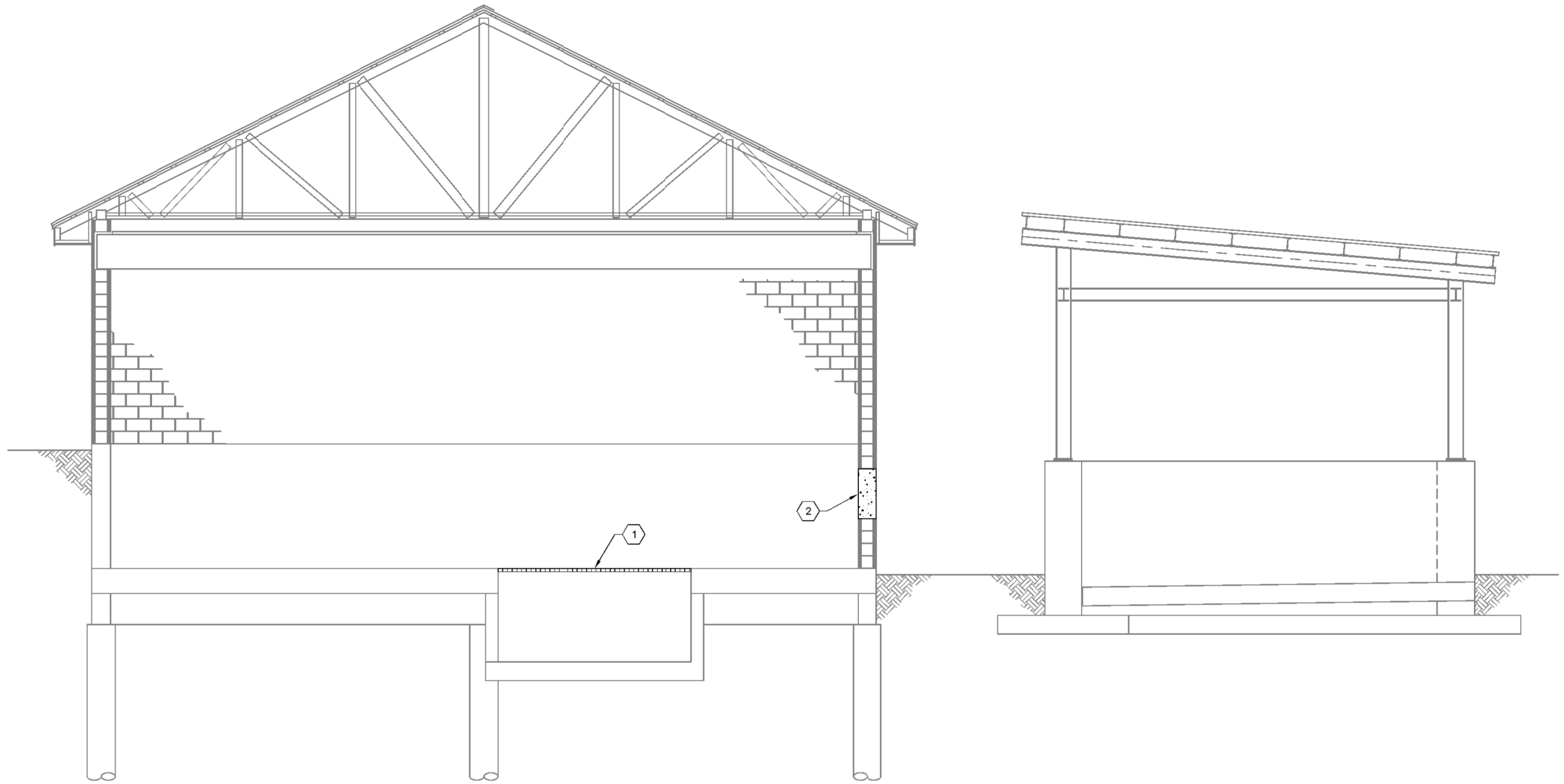
SHEET
06D301

GENERAL NOTES:

A.

KEY NOTES:

1. INSTALL NEW GRATING OVER EXISTING OPENING.
2. FILL EXISTING WALL OPENING, SEE DETAIL X/XXXXXX.



B / 06D101 SECTION
SCALE: 1/4" = 1'-0"

c:\pwworking\central01\d1010478\06D302.dwg, Plot, 2/1/2019 8:34:33 AM, KBREWSTE

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	ADAM S. PARMENTER
CIVIL	
ARCHITECTURAL	
STRUCTURAL	
PROCESS	
MECHANICAL	
ELECTRICAL	
DRAWN	K. BREWSTER
PROJECT NUMBER	10114361

TOWN OF ERIE 1874

TOWN OF ERIE, CO
NRWF IMPROVEMENTS

UV/DEWATERING BUILDING SECTION

0 1" 2"

FILENAME 06D302.dwg

SCALE AS NOTED

SHEET 06D302