



CITY OF OREM
CITY COUNCIL MEETING
56 North State Street, Orem, Utah
February 28, 2023

*This meeting may be held electronically
to allow a Councilmember to participate.*

3:00 P.M. TOUR OF THE PROVO/OREM DISPATCH CENTER

3:30 P.M. WORK SESSION - CITY CONFERENCE ROOM

- 1 PRESENTATION - Lakeview Parkway Project - Inter-Local Cooperation Agreement (20 minutes)**
Presenter: Sam Kelly, City Engineer
- 2 DISCUSSION - North Utah County Aquifer Council (15min)**
Presenter: Reed Price, Assistant Public Works Director
- 3 DISCUSSION - Review potential amendments to the landscaping ordinance. (20 min)**
Presenter: Jason Bench, Planning Division Manager
- 4 PRESENTATION - Impact Fee Study (30min)**
Presenter: Trevor Bell, Procurement & Budget Manager & Chris Tschirki, Public Works Director
- 5 PRESENTATION - Utah Valley Drug Prevention (10min)**
Presenter: Wendy Wright, Health Educator Injury Prevention/Asthma
- 6 DISCUSSION - Proposed Ordinance Amendment Creating the Management Services Department (15min)**
Presenter: Steve Earl, City Attorney

1. AGENDA REVIEW & PREVIEW OF UPCOMING AGENDA ITEMS

The City Council will review the items on the agenda.

2. CITY COUNCIL REPORTS (BOARDS & COMMISSIONS, NEW BUSINESS, ETC.)

This is an opportunity for members of the City Council to raise issues of information or concern.

6:00 P.M. REGULAR SESSION - COUNCIL CHAMBERS

3. CALL TO ORDER
4. INVOCATION/INSPIRATIONAL THOUGHT: Jim Lauret
5. PLEDGE OF ALLEGIANCE: Cub Scout From Pack 1776
6. MAYOR'S REPORT/ITEMS REFERRED BY COUNCIL

7. PERSONAL APPEARANCES – 15 MINUTES

Time has been set aside for the public to express their ideas, concerns, and comments on items not scheduled as public hearings on the Agenda. Those wishing to speak are encouraged to show respect for those who serve the city. Comments should focus on issues concerning the city. Those wishing to speak should have signed in before the beginning of the meeting. (Please limit your comments to 3 minutes or less.)

8. SCHEDULED ITEMS

8.1 REAPPOINTMENT - Arts Council

-Dave Blackinton & John Reinhard

8.2 REAPPOINTMENT - Public Works Advisory Commission

- Tod Hadley

8.3 APPOINTMENT - Public Works Advisory Commission

- Mike Whimpey

8.4 APPOINTMENT - City Recorder

-Teresa McKittrick

8.5 APPOINTMENT - Library Commission

- Debbie Smith

8.6 RESOLUTION - Dispatch Services Agreement

A Resolution approving a dispatch services agreement, appropriating \$1,642,862 in the newly created Emergency Response Fund, and transferring \$676,520 of existing funds to accommodate the combining of Orem and Provo dispatch services. (23-009).

Presenter: Jake Summers, Deputy City Attorney

8.7 RESOLUTION - Appointing Brenn Bybee as the city's representative to the Utah Infrastructure Agency Board of Directors, the Utah Risk Management Agency Board of Directors and the Alternate Representative to the UTOPIA Board of Directors.

Presenter: Steve Earl, City Attorney

8.8 PUBLIC HEARING – Amending portions of Section 22-8-8(A) *General Zone Development Standards* pertaining to overall height requirements for a parapet wall for municipal buildings located in a C2 zone.

Presenter: Jason Bench, Planning Division Manager

8.9 RESOLUTION - Adopt the 2022 Orem Water Reclamation Facility Capital Facilities Plan

Presenter: John Matta, WaterWorks Engineers; Chris Tschirki, Public Works Director; Reed Price, Assistant Public Works Director; Giles Demke, Water Reclamation Section Manager

9. COMMUNICATION ITEMS

10. CITY MANAGER INFORMATION ITEMS

This is an opportunity for the City Manager to provide information to the City Council. These items

are for information and do not require action by the City Council.

11. ADJOURN

THE PUBLIC IS INVITED TO PARTICIPATE IN ALL CITY COUNCIL MEETINGS.

**If you need a special accommodation to participate in the City Council Meetings and Study Sessions, please call the City Recorder's Office at least 3 working days prior to the meeting.
(Voice 801-229-7000)**

This agenda is also available on the City's webpage at orem.org

2-6-1. City Administration.

A. The administration of the City shall be conducted by and through the City Manager's Office and the following operating departments:

1. City Manager's Department. The City Manager's Department provides oversight to all of the operating departments of the City and implements City Council policies.

2. Finance Department. The Finance Department provides the following functions for the City: Finance, Budgeting, Treasury, Customer Service/311, Purchasing, Payroll and Accounting. The department also has a liaison relationship with the Justice Court.

3. Development Services Department. The Development Services Department works with contractors, other City Departments, State agencies and the public to design, build and maintain City infrastructure and buildings, oversees business licensing, and reviews/monitors all private development and construction in the City.

4. Fire Department. The Fire Department saves lives and protects property and the environment through fire suppression, paramedic emergency medical services, and other special response emergency services.

5. Legal Services Department. The Legal Services Department provides legal counsel and support to the City Council and City departments; it also prosecutes misdemeanor crimes committed in Orem.

6. Orem Public Library. The Orem Public Library provides print and nonprint media items, reference and advisory service, cultural programs, and fine art and touring exhibits).

7. Police Department. The Police Department enforces the law, preserves the peace, maintains order, resolves problems, and provides a safe and secure environment for all citizens and visitors to the City of Orem.

8. Public Works Department. The Public Works Department operates and maintains streets, sidewalks, parks, cemetery, street signs, street striping, traffic signals, fiber optics, fleet services, and water, storm water, waste water and street lighting utilities.

9. Recreation Department. The Recreation Department offers fitness, recreation, leisure, learning, and sports opportunities for all ages, across a wide spectrum of outdoor and indoor venues and interests.

10. Management Services Department. The Management Services Department provides Human Resources, Risk Management, Information Technology and Communications services for the City. It also includes the office of the City Recorder.

B. Each department shall be administered by a director, who shall be the head of that department.

C. Department directors shall be appointed by the City Manager, subject to the provisions of this Chapter.

D. Each department director shall have the authority, under the general supervision of the City Manager, to take any action necessary to accomplish the duties and responsibilities of the director's office, as well as those duties and responsibilities imposed by law or the City Manager.

RESOLUTION NO. _____

A RESOLUTION OF THE OREM CITY COUNCIL APPOINTING BRENN BYBEE AS THE CITY'S REPRESENTATIVE TO THE UTAH INFRASTRUCTURE AGENCY BOARD OF DIRECTORS, THE CITY'S REPRESENTATIVE TO THE UTAH RISK MANAGEMENT AGENCY AND THE ALTERNATE REPRESENTATIVE TO THE UTOPIA BOARD OF DIRECTORS

WHEREAS the City has the right to appoint a member of the Utah Infrastructure Agency (UIA) Board of Directors and an alternate member of the Utopia Board of Directors; and

WHEREAS the City also has the right to appoint a member of the Utah Risk Management Agency Board of Directors; and

WHEREAS the City Council desires to appoint Brenn Bybee as the City's member of the Utah Infrastructure Agency Board of Directors, the City's member of the Utah Risk Management Agency Board of Directors and the City's alternate member of the Utopia Board of Directors; and

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF OREM, UTAH, as follows:

1. The City Council hereby appoints Brenn Bybee to serve as the City's member of the Utah Infrastructure Agency Board of Directors, the City's member of the Utopia Board of Directors and as the City's alternate member of the Utopia Board of Directors.
2. This resolution shall become effective immediately upon passage.

PASSED and APPROVED this 28th day of February, 2023.

David A. Young, Mayor

ATTEST:

Tess Jones, Deputy City Recorder

COUNCILMEMBER	AYE	NAY	ABSTAIN
Mayor David A. Young	☐	☐	☐
Jeff Lambson	☐	☐	
Debby Lauret	☐	☐	
Tom Macdonald	☐	☐	
LaNae Millett	☐	☐	
Terry Peterson	☐	☐	
David Spencer	☐	☐	

CITY OF OREM
CITY COUNCIL MEETING
FEBRUARY 28, 2023



REQUEST:	6:00 P.M. SCHEDULED ITEM PUBLIC HEARING – Amending portions of Section 22-8-8(A) <i>General Zone Development Standards</i> pertaining to overall height requirements for a parapet wall for municipal buildings located in a C2 zone.
APPLICANT:	Development Services
FISCAL IMPACT:	None

NOTICES:

- Posted in 2 public places
- Posted on City webpage
- Posted on the State noticing website
- Faxed to newspapers
- Posted at utah.gov/pa

SITE INFORMATION:

General Plan Designation:
Community Commercial
Current Zone: **C2**
Acreage: **N/A**
Neighborhood: **Various**

**PLANNING
COMMISSION
RECOMMENDATION**
4-3 for Approval

PREPARED BY:
Jason Bench, AICP
Planning Division
Manager

REQUEST: The applicant requests the City amend Section 22-8-8(A) pertaining to the overall height of a parapet wall located within the C2 zone pertaining to municipal buildings.

BACKGROUND:

The Development Services Department requests an amendment to Section 22-8-8(A) of the Orem City Code pertaining to the overall height of a parapet wall in a C2 zone. Currently, the maximum height in the C2 zone is 35 feet if located within 100 feet of a residential zone and 48 feet if located greater than 100 feet from a residential zone. The overall height of a parapet wall is included in the overall height requirements.

In connection with the development of the new City Center municipal building, the architects suggest an overall height of the building to be 48 feet to maximize the ceiling space in the Council Chambers and in other areas of the building. As a result, the parapet wall be an additional four (4) feet above the 48-foot maximum height.

The proposed ordinance amendment allows the additional four feet of parapet walls to extend an additional four (4) feet above the maximum height requirement for municipal buildings only. This allows additional flexibility of building design, however, is limited to municipal buildings located in a C2 zone. The proposed amendment is part of the staff report for your review.

The proposed amendments pertain to parapets only. All other requirements would remain the same.

RECOMMENDATION: The Planning Commission recommends the City Council, by ordinance, amend Section 22-8-8(A) *General Development Standards* pertaining to parapet wall heights in the C2 zone for municipal buildings only.

22-8-8. Zone Development Standards.

- A. **General Zone Development Standards.** The following development standards shall apply in the PO, C1, C2, C3, and HS zones.

Zone Development Standards Commercial and Professional Office Zones					
	PO	C1	C2	C3	HS
Minimum Lot area in square feet unless listed as acres Setbacks (Minimum)	18000*****	7000	7000	3 acres*	½ acre
From back of sidewalk adjacent to State Street or State Street Connector Street:	15'	15'	15'	15'	15'
From all other streets:	20'**	20'	20'*****	30'**	20'
From an adjoining Property in a nonresidential zone:	0	0	0	0	0
From an adjoining property in a residential zone****:	25'*****	10'	10'	40'	10'
Structure Heights.					
Minimum:	8'	8'	8'	8'	8'
Maximum:	35'	48'	48'***	35'***	60'
* Parcels smaller than three (3) acres shall only be allowed pursuant to Section 22-8-14(D). ** <u>Building setbacks</u> from 800 North in the PO and C3 zones shall be according to "Appendix I" §22 8-9 ZONING *** Exception: The maximum height for <u>structures</u> located in the C3 zone which are set back no less than one hundred fifty feet (150') from a residential zone shall be forty-eight feet (48'). The maximum heights for structures in a C2 zone which are set back less than one hundred feet (100') from a residential zone shall be thirty-five (35') feet. <u>Notwithstanding the above, the height of municipal building parapets may extend an additional four (4') feet above the maximum building height in the C2 zone.</u> **** In all commercial zones no portion of any building shall be located closer to a residentially zoned property than a distance equal to the height of that portion of the building (applicable to all commercial zones listed above). However, no setback is required where the top of the structure is lower than the grade of the adjoining residential lot (as measured at some point within five feet of the property line) along the entire length of the property line between the two properties. ***** Building setbacks and landscaping requirements for lots located adjacent to State Street shall be measured from the back of an existing or required sidewalk. All buildings and parking lots shall be set back at least fifteen feet (15') from any required sidewalk adjacent to State Street (adjacent sidewalks include sidewalks separated from State Street by a landscape strip). ***** The PO zone may not be applied to an area of less than one acre. NOTE: In all commercial zones, except the PO and C3 zones, belfries, cupolas, domes not used for human occupancy, chimneys, ventilators, sky lights, cornices, antennas, and properly screened mechanical appurtenances may extend up to an additional ten feet above the maximum height allowed in the applicable zone. However, the combination of such items occupy more than thirty percent 30% of the area of the uppermost floor of the building.					

Parapet Wall Examples



ORDINANCE NO. _____

AN ORDINANCE BY THE OREM CITY COUNCIL AMENDING A PORTION OF SECTION 22-8-8(A) *GENERAL ZONE DEVELOPMENT STANDARDS* PERTAINING TO OVERALL HEIGHT REQUIREMENTS OF A PARAPET WALL FOR MUNICIPAL BUILDINGS LOCATED IN THE C2 ZONE.

WHEREAS on November 14, 2022, the Development Services Department filed an application with the City of Orem requesting the City amend Section 22-8-8(A) *General Zone Development Standards* to allow a parapet wall for municipal buildings to extend four (4) feet above the maximum height in the C2 zone; and

WHEREAS a public hearing considering the subject application was held by the Planning Commission on January 18, 2023; and

WHEREAS a public hearing considering the subject application was held by the City Council on February 28, 2023; and

WHEREAS the agenda of the City Council meeting at which the subject application was heard was posted at the Orem Public Library, on the Orem City webpage and at the City offices at 56 North State Street; and

WHEREAS the matter having been submitted and the City Council having fully considered the request as it relates to the health, safety, and general welfare of the City; the orderly development of land in the City; the effect upon surrounding neighborhoods; and the special conditions applicable to the request.

NOW THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF OREM, UTAH, as follows:

1. The City Council finds the request to allow a parapet wall to exceed the maximum height limit by an additional four (4) feet for municipal buildings in the C2 zone is reasonable and is in the best interest of the City.
2. The City Council hereby amends a portion of Section 22-8-8(A) *General Zone Development Standards* with respect to height limits in the C2 zone, as shown in Exhibit "A" which is attached hereto and incorporated herein by reference.

3. This ordinance shall take effect immediately upon passage and publication in a newspaper of general circulation in the City of Orem.
4. If any part of this ordinance shall be declared invalid, such decision shall not affect the validity of the remainder of this ordinance.
5. All other ordinances or policies in conflict herewith, either in whole or part, are hereby repealed.

PASSED, APPROVED and ORDERED PUBLISHED this 28th day of February 2023.

David A. Young, Mayor

ATTEST:

Tess Jones, Deputy City Recorder

COUNCILMEMBER	AYE	NAY	ABSTAIN
Mayor David A. Young	☐	☐	☐
Jeff Lambson	☐	☐	☐
Debby Lauret	☐	☐	☐
Tom Macdonald	☐	☐	☐
LaNae Millett	☐	☐	☐
Terry Peterson	☐	☐	☐
David Spencer	☐	☐	☐

Exhibit "A"

22-8-8. Zone Development Standards.

- A. **General Zone Development Standards.** The following development standards shall apply in the PO, C1, C2, C3, and HS zones.

Zone Development Standards Commercial and Professional Office Zones					
	PO	C1	C2	C3	HS
Minimum Lot area in square feet unless listed as acres Setbacks (Minimum)	18000*****	7000	7000	3 acres*	½ acre
From back of sidewalk adjacent to State Street or State Street Connector Street:	15'	15'	15'	15'	15'
From all other streets:	20'**	20'	20'*****	30'**	20'
From an adjoining Property in a nonresidential zone:	0	0	0	0	0
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Structure Heights.					
Minimum:	8'	8'	8'	8'	8'
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* Parcels smaller than three (3) acres shall only be allowed pursuant to Section 22-8-14(D). ** <u>Building setbacks</u> from 800 North in the PO and C3 zones shall be according to "Appendix I" §22 8-9 ZONING *** Exception: The maximum height for <u>structures</u> located in the C3 zone which are set back no less than one hundred fifty feet (150') from a residential zone shall be forty-eight feet (48'). The maximum heights for structures in a C2 zone which are set back less than one hundred feet (100') from a residential zone shall be thirty-five (35') feet. <u>Notwithstanding the above, the height of municipal building parapets may extend an additional four (4') feet above the maximum building height in the C2 zone.</u> **** In all commercial zones no portion of any building shall be located closer to a residentially zoned property than a distance equal to the height of that portion of the building (applicable to all commercial zones listed above). However, no setback is required where the top of the structure is lower than the grade of the adjoining residential lot (as measured at some point within five feet of the property line) along the entire length of the property line between the two properties. *****Building setbacks and landscaping requirements for lots located adjacent to State Street shall be measured from the back of an existing or required sidewalk. All buildings and parking lots shall be set back at least fifteen feet (15') from any required sidewalk adjacent to State Street (adjacent sidewalks include sidewalks separated from State Street by a landscape strip). *****The PO zone may not be applied to an area of less than one acre. NOTE: In all commercial zones, except the PO and C3 zones, belfries, cupolas, domes not used for human occupancy, chimneys, ventilators, sky lights, cornices, antennas, and properly screened mechanical appurtenances may extend up to an additional ten feet above the maximum height allowed in the applicable zone. However, the combination of such items occupy more than thirty percent 30% of the area of the uppermost floor of the building.					

**A RESOLUTION OF THE OREM CITY COUNCIL ADOPTING THE
2022 OREM WATER RECLAMATION FACILITY CAPITAL FACILITIES PLAN**

WHEREAS, the City of Orem operates a Water Reclamation Utility, which includes the Orem Water Reclamation Facility (OWRF); and

WHEREAS, the OWRF provides an essential service to treat wastewater which protects the environment and enhances the quality of life for the citizens of Orem; and

WHEREAS, the OWRF was originally constructed in 1957 with significant upgrades made to the facility in 1984, 1998, and 2010; and

WHEREAS, the City Council adopted the 2016 Sewer Master Plan which was later updated in 2021, which identified the need to further study and develop a capital facilities plan at the OWRF; and

WHEREAS, in 2021, the City hired WaterWorks Engineers to conduct a capital facilities plan for the OWRF; and

WHEREAS, a complete analysis of current facility operations was performed to determine current and buildout flows and load, liquid and solid stream process performance, hydraulic performance, power distribution system performance, odor control measures throughout the facility, and an assessment of the condition of equipment and facilities and their relative risk of failure; and

WHEREAS the plan recommends improvements to the OWRF that are driven by aging equipment and facilities, failure of older structures to meet current building and safety code (NFPA 820) requirements, inadequate process redundancy, hydraulic bottlenecks, lack of odor control, and suboptimal process performance with respect to permitted effluent requirements and classification of biosolids for land applications; and

WHEREAS, based on the complete facility analysis, a four-phase implementation plan over the next twenty years was developed with estimated costs totaling \$160 Million (present value); and

WHEREAS, these improvements are needed to ensure the long-term viability of the OWRF; and

WHEREAS, the 2022 Capital Facilities Plan was presented to and discussed with the City Council during a work session on January 10, 2023.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF OREM, as follows:

1. The Orem City Council hereby amends the 2021 Sewer Master Plan to include the 2022 Orem Water Reclamation Capital Facilities Plan which is attached hereto as Exhibit “A” and incorporated herein by reference.

2. The Orem City Council hereby directs staff to prepare a financial plan and utility rate study to provide options for the funding of the improvements identified in the 2022 Orem Water Reclamation Capital Facilities Plan.
3. All other resolutions and policies in conflict herewith, either in whole or in part, are hereby repealed.
4. This Resolution shall become effective immediately upon passage.

PASSED and APPROVED this 28th day of February, 2023.

David A. Young, Mayor

ATTEST:

Tess Jones, Deputy City Recorder

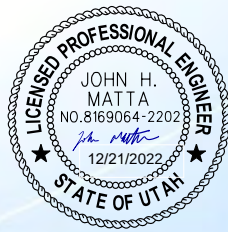
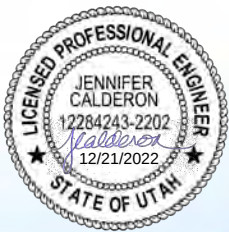
COUNCILMEMBER	AYE	NAY	ABSTAIN
Mayor David A. Young	☐	☐	☐
Jeff Lambson	☐	☐	☐
Debby Lauret	☐	☐	☐
Tom Macdonald	☐	☐	☐
LaNae Millett	☐	☐	☐
Terry Peterson	☐	☐	☐
David Spencer	☐	☐	☐

Exhibit "A"



Orem Water Reclamation Facility Capital Facilities Plan

December 21, 2022



WATERWORKS
ENGINEERS



OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
CAPITAL FACILITIES PLAN

OREM WATER RECLAMATION FACILITY
CAPITAL FACILITIES PLAN

Date: 12/21/2022
Prepared By: Jenny Calderon, P.E.
Reviewed By: Wayne Fausett
David Kopchynski, PhD, P.E.
John Matta, P.E.

Table of Contents

Executive Summary.....	4
1. Introduction and Background	10
1.1. City of Orem	10
1.2. Orem Water Reclamation Facility (OWRF)	10
2. Acronyms and Abbreviations.....	10
3. Existing and Future Conditions	11
3.1. Project Needs and Planning	11
3.2. Existing and Projected Wastewater Flows.....	13
3.3. Effluent Limits	13
3.3.1. Current and Projected Waste Loads	14
4. Environmental Review	15
4.1. Flood Plains and Seismic Risk.....	15
4.2. Air Quality and Odor Control	19
5. Performance and Condition Assessment Summary Review by Process Area	20
6. Development of Alternatives.....	22
6.1. No Action	23
6.2. Wastewater Management Techniques	23
6.2.1. Conventional Technologies.....	23



6.2.2. Alternative Technologies	24
6.2.2.1. Ammonia Based Aeration Control (ABAC).....	24
6.2.2.2. Partial Bypass of Primary Influent to Bioreactors	24
6.2.2.3. Chemical Addition	24
6.2.3. Sidestream Treatment	24
6.2.3.1. Post Aerobic Digestion (PAD)	26
6.2.3.2. Biosolids Aeration.....	26
6.2.3.3. Vacuum Degassing of Biosolids	27
6.3. Recommended Upgrades to the Existing OWRF Facility	27
6.4. Staged Construction and Capital Finance Planning	30

List of Tables

Table 0-1 – Recommended Upgrades and Estimated Costs.....	4
Table 2-1 – Acronyms and Abbreviations	10
Table 3-1 – Existing and Projected OWRF Influent Wastewater	13
Table 3-2 – Current OWRF Effluent Limitations from UPDES Permit #UT0020915	14
Table 3-3 – OWRF Load Summary	15
Table 5-1 – Predicted Treatment Process Performance at Design Flow and ADMM Load	20
Table 6-1 – Predicted Process Performance at Design Flow / ADMM Load with Biosolids Thickening...	25
Table 6-2 – Recommended OWRF facility Upgrades by Process.....	27
Table 6-3– OWRF - Facility Plan Cost Estimate and Phasing plan	34

List of Figures

Figure 0-1 – Phase 1 Recommended OWRF Upgrades.....	6
Figure 0-2 – Phase 2 Recommended OWRF Upgrades.....	7
Figure 0-3 – Phase 3 Future OWRF Upgrades.....	8
Figure 0-4 –Phase 4 Future OWRF Upgrades.....	9
Figure 4-1 – FEMA Flood Plain Map for Orem City	17
Figure 4-2 – Liquefaction Hazard map for OWRF	18

Figure 4-3 – Wind Rose at Provo Municipal Airport from January 2017 to December 2020.....	19
Figure 6-1 – Phase 1 Future OWRF Upgrades.....	36
Figure 6-2 – Phase 2 Future OWRF Upgrades.....	37
Figure 6-3 – Phase 3 Future OWRF Upgrades.....	38
Figure 6-4 – Phase 4 Future OWRF Upgrades.....	39

Appendixes

APPENDIX A. Flows and Loads Technical Memorandum	40
APPENDIX B. Hydraulic Capacity Technical Memorandum	62
APPENDIX C. Treatment Process Evaluation Memorandum	82
APPENDIX D. Biosolids Management Technical Memorandum.....	116
APPENDIX E. Condition Assessment Technical Memorandum	155
APPENDIX F. Odor Control Memorandum	220
APPENDIX G. Power Distribution Study.....	257

Executive Summary

The City of Orem, Utah (City) has a buildout population of 129,000 people. According to current population growth projections, the City will reach this population capacity by approximately 2060. Using influent flows and loads data from the Orem Wastewater Treatment Facility (OWRF) for the period between 2017 and 2020, the projected influent average annual day flow rate at buildout is expected to be approximately 13.5 mgd, which is equal the facility's current rated capacity.

The OWRF was originally constructed in 1957. Significant upgrades to the facility were constructed in 1984 and 2010. Rated effluent limits and current and anticipated regulations determine the overall capacity of the facility. Utah State's Total Biological Phosphorus Effluent Limit (TBPEL) rule was promulgated in 2020, and is expected to be approved to go into full effect at the OWRF on January 1, 2025. This rule states that effluent Total Phosphorus (TP) shall not exceed 1 mg/L annual average. The promulgation of new regulations limiting effluent on Total Inorganic Nitrogen to 10 mg/L are anticipated in the near future.

A complete analysis of current facility operations was performed to determine current and buildout flows and loads, liquid and solid stream process performance, hydraulic performance, power distribution system performance, odor control measures throughout the facility, and an assessment of the condition of equipment and facilities and their relative risk of failure. This analysis is summarized in seven technical memoranda attached to this document as APPENDIXES A through G.

This document recommends upgrades to the OWRF that are driven by aging equipment and facilities, failure of older structures to meet current building and safety code (NFPA 820) requirements, inadequate process redundancy, hydraulic bottlenecks, lack of odor control, and suboptimal process performance with respect to permitted effluent requirements and classification of biosolids for land applications.

Based on the complete facility analysis, a three phase upgrade plan was developed with estimated costs associated with each. These are summarized in the table below.

Table 0-1 – Recommended Upgrades and Estimated Costs

<i>Phase</i>	<i>Recommended Upgrades</i>	<i>Estimated Cost</i>
Phase 1 includes facilities that pose immediate safety hazards, do not meet building and safety codes, obsolete equipment, lack of redundancy and compromised process performance	Upgrade grit system Primary Clarifier upgrades Replace Primary Effluent/Screw Pump Station and pumps Primary Sludge Pump Station Upgrades Improvements to Oxidation Ditches Replace Secondary Clarifier equipment and mechanisms Expand UV disinfection New Odor control systems for headworks, primary treatment, and biosolids handling processes Refurbish Existing Thickening Process	\$58,000,000

	Mesophilic Primary Digester Control Building, and ancillary equipment. Replace Secondary Digester Cover Upgrade and expand Biosolids Building and equipment to allow for expanded capacity Construct redundant waste gas flare Install sidestream phosphorus / struvite mitigation system Electrical System / site power Upgrades to SCADA programming and system integration New Maintenance Building	
Phase 2 includes aging facilities, Continued Code requirements upgrades, Facilities and equipment in adequate condition but high risk of failure	Replace Headworks facility Replace RAS/WAS pump station structure and equipment New Odor control systems for headworks, primary treatment, and biosolids handling processes Install new thickening process Construct a redundant thermophilic/mesophilic digester Install tankage for pressate equalization Mesophilic primary Digester: Replace digester cover Electrical system / site power	\$40,000,000
Phase 3 includes aging facilities in adequate condition at moderate to low risk of failure	Replace grit removal system Install a new Renewable Natural Gas (RNG) system Grading, paving, site drainage improvements Landscaping and aesthetics as required New Impure Water Pump Station Upgrades to SCADA programming and system integration Site Demolition as required Various site upgrades as necessary	\$25,000,000
Phase 4 address potential future regulations, enhance sustainability and redundancy	Install new mesophilic digester Modify existing bioreactors to act as plug flow reactors to address potential nitrogen regulations Install a redundant bioreactor	\$37,000,000

Figure 0-1, Figure 0-2, Figure 0-3, and Figure 0-4 depict the site plan and corresponding phases.

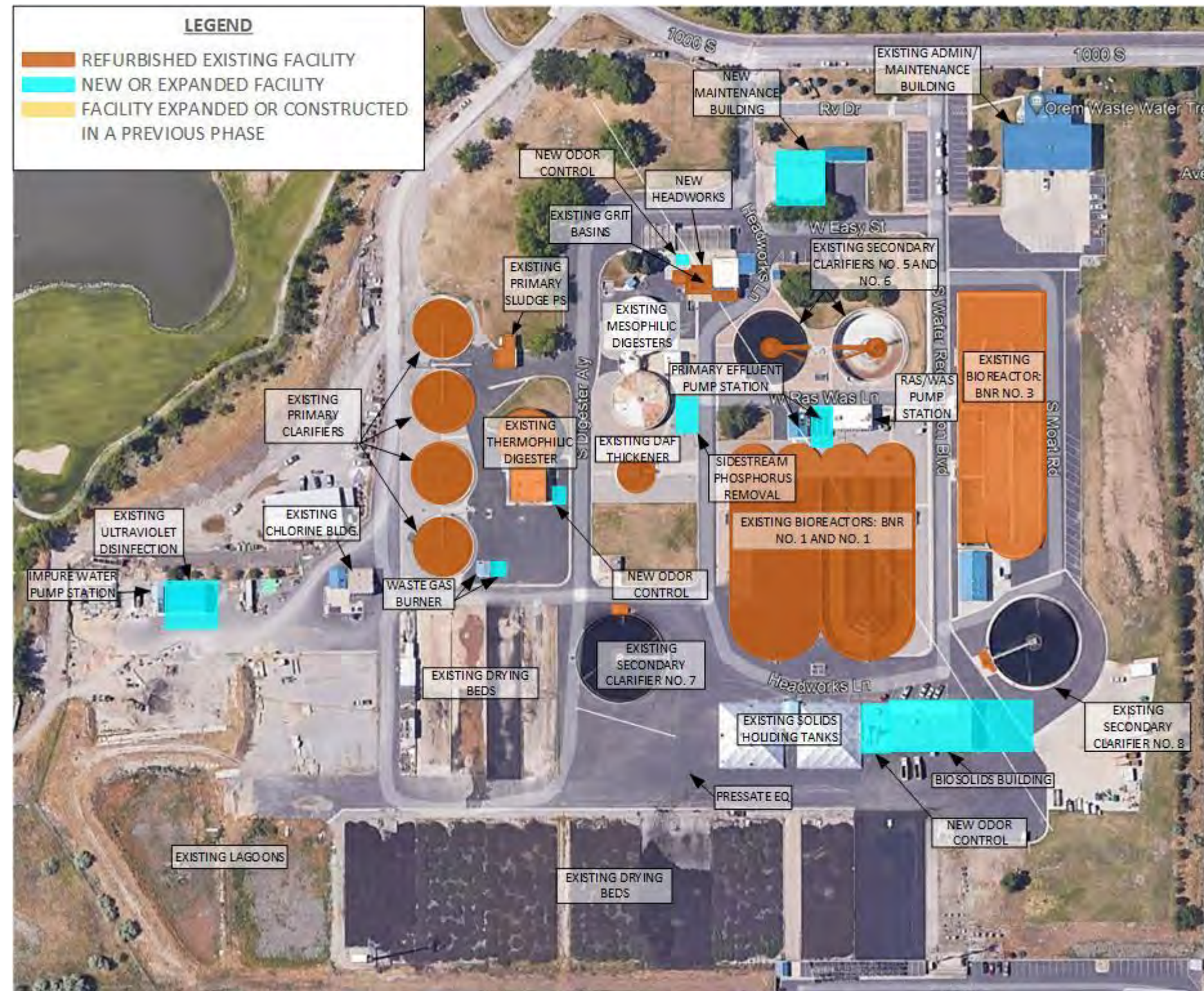


Figure 0-1 – Phase 1 Recommended OWRF Upgrades

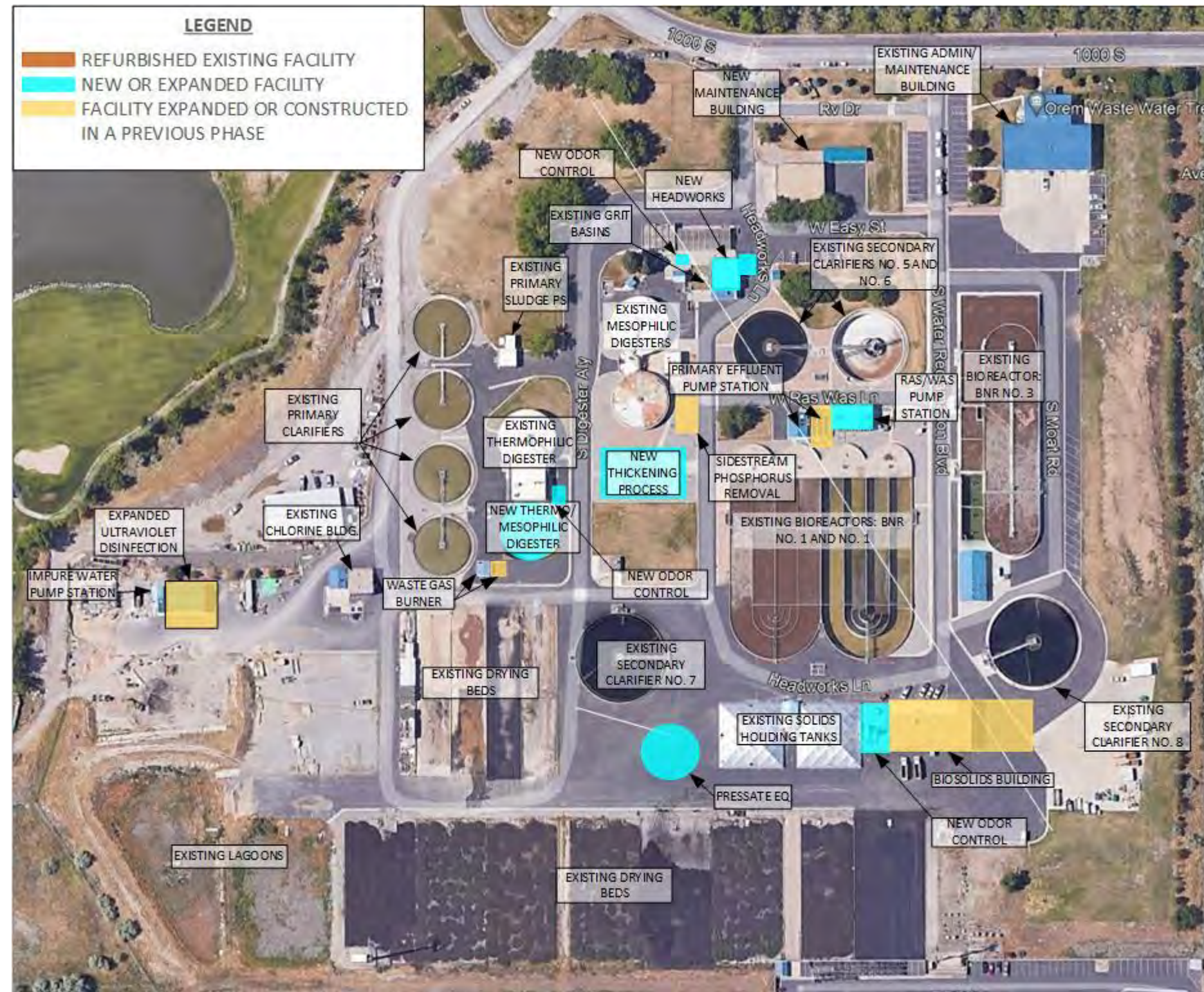


Figure 0-2 – Phase 2 Recommended OWRF Upgrades

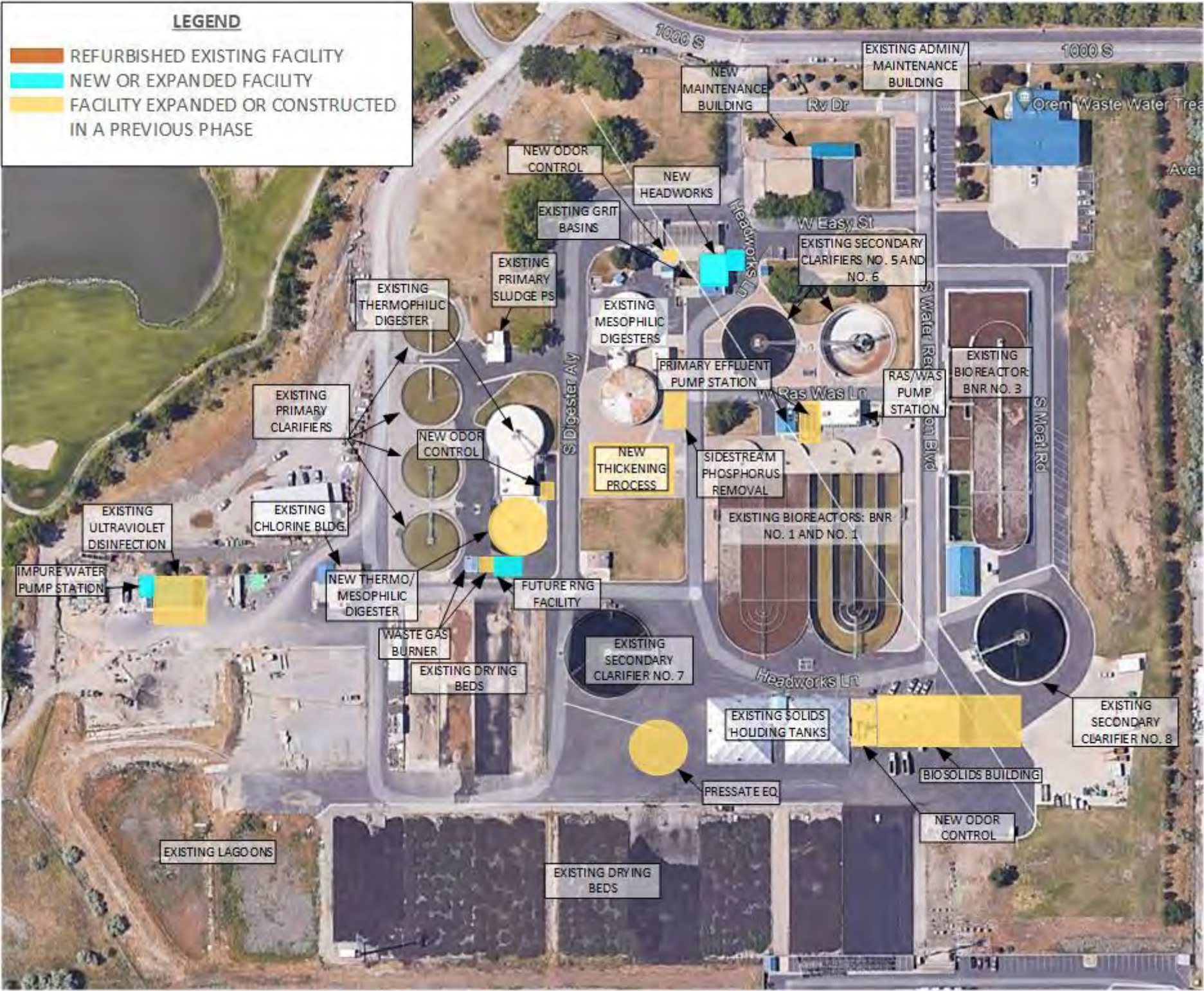


Figure 0-3 – Phase 3 Future OWRF Upgrades

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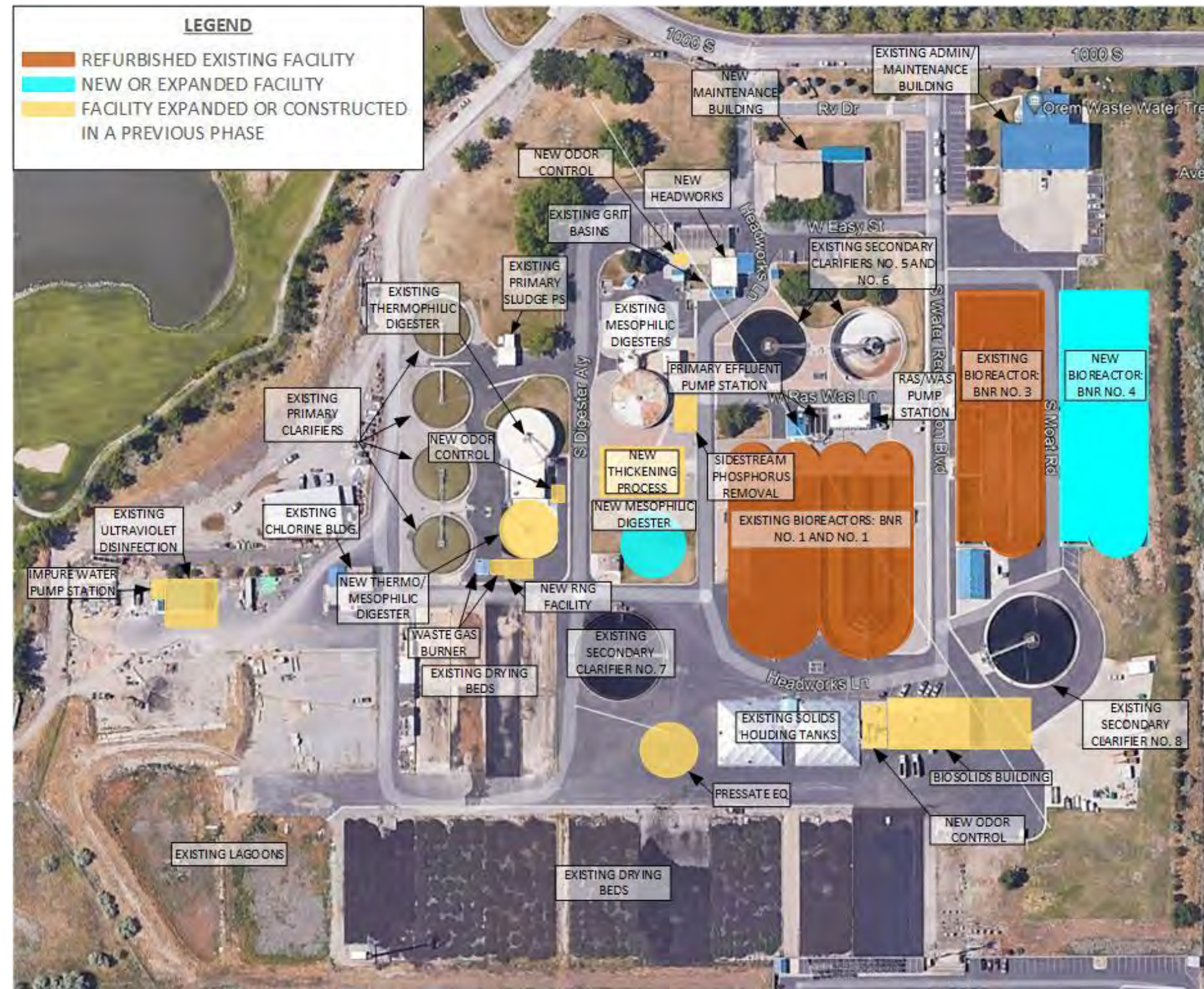


Figure 0-4 –Phase 4 Future OWRF Upgrades

1. Introduction and Background

1.1. City of Orem

The City of Orem, Utah (the City) is the fifth largest city in Utah. The City is located East of Utah Lake, and is bordered on the East by the Wasatch Mountains, on the West by the City of Vineyard and Utah Lake, and on the North and South by Lindon City and Provo City, respectively. The municipality is largely developed and is land locked. Therefore, geographic expansion is limited. The City sewer collection system and Orem Water Reclamation Facility (OWRF) extend into and serve all developed areas of the City, except for a few areas in the South of the City that are served by the Provo City collections system. The collection system also extends into some areas of Lindon and Vineyard, due to topography and to the historical development of the municipalities. The 2020 service population was estimated to be approximately 111,000 in Orem's 2020 Sewer Master Plan. The City's service population has reached 85% of its projected building population of 129,900. Based on growth projections and current zoning, buildout is estimated to be reached by 2060.

1.2. Orem Water Reclamation Facility (OWRF)

Construction of the OWRF was initially completed in 1957, and consists of headworks, primary clarification, oxidation ditches modified for biological nutrient removal, secondary clarification, and UV disinfection. Solids from primary and secondary clarification are anaerobically digested using mesophilic and thermophilic digesters. Digested sludge is dewatered and currently land applied. The facility was upgraded in 2010 and is rated for the production of Class A biosolids. Currently, only Class B biosolids are produced.

This document summarizes investigations into the condition and criticality of facilities and equipment, as well as into the flows and loads, hydraulic capacity, liquid and solids stream treatment capacity, odor control systems, electrical systems and control systems. This analysis of the OWRF culminates in a summary of recommended facility improvements, estimated costs of the upgrades, and a phasing plan for implementation.

2. Acronyms and Abbreviations

Table 2-1 provides a list of acronyms and abbreviations in the Capital Facilities Plan.

Table 2-1 – Acronyms and Abbreviations

Abbreviation or Acronym	Word or Phrase
AAD	Annual Average Daily Flow Rate
ABAC	Ammonia Based Aeration Control
ADMM	Average Day Maximum Monthly Flow Rate
AGS	Activated Granular Sludge
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand

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Abbreviation or Acronym	Word or Phrase
DAF	Dissolved Air Flotation
DAF	Dissolved Air Flotation Thickener
DEQ	State of Utah Department of Environmental Quality
DO	Dissolved Oxygen
DWQ	State of Utah Division of Water Quality
FEMA	Federal Emergency Management Agency
MAG	Mountainland Association of Governments
MBR	Membrane Bioreactor
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
NFPA	National Fire Protection Association
NH ₃ -N	Ammonia as Nitrogen
Ortho-P	Orthophosphates
OWRF	Orem Water Reclamation Facility
PDF	Peak Daily Flow Rate
PHF	Peak Hourly Flow Rate
RAS	Return Activated Sludge
RNG	Renewable Natural Gas
SRT	Solids Retention Time
TAN	Total Ammonia Nitrogen
TBPEL	Technology Based Phosphorus Effluent Limit
TIN	Total Inorganic Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UPDES	Utah Pollutant Discharge Elimination System
UV	Ultra-Violet
WAS	Waste Activated Sludge
WRF	Water Reclamation Facility
WWTP	Wastewater Treatment Plant

3. Existing and Future Conditions

3.1. Project Needs and Planning

Aging and insufficient facility assets coupled with current and anticipated regulatory changes have prompted the City to look into upgrades, process modifications and process optimization to help the City maintain the current level of service as well as meet future community goals and regulatory

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Water Works Engineers, LLC

requirements. The OWRF was designed to meet the City's projected buildout capacity. However, there are some capacity issues related to lack of redundancy, hydraulic performance, new and anticipated regulatory requirements, and equipment that is not performing optimally.

In addition to the condition of aging facilities, there is concern that many existing facilities do not meet the latest seismic code requirements. Also, because much of the electrical equipment was last upgraded in the mid-1980s, it does not meet the National Fire Protection Association's Standard for Fire Protection in Wastewater Treatment Facilities and Collection Systems (NFPA 820), which outlines requirements for protecting wastewater treatment facilities and their associated collections systems against fire and explosion hazards. These deficiencies are not only significant safety concerns but could result in damage to or failures of key processes that could impede OWRF operations. All future upgrades should include structural and electrical upgrades to meet current building code requirements.

OWRF has identified the need for an up-to-date Capital Facilities Plan to address various drivers including age and condition of facilities, employee safety, building and engineering codes, water quality regulations, and capacity and process performance of the liquid and solid streams. The analyses and findings were discussed and documented in detail in the following Technical Memoranda (TM):

1. Flows and Loads Technical Memorandum (APPENDIX A): This TM discusses community growth and anticipated flows and loads that are expected through community buildout, which is estimated to be by the year 2060.
2. Hydraulic Capacity Technical Memorandum (APPENDIX B): This TM discusses the hydraulic capacity of the existing OWRF, identifies potential hydraulic bottlenecks, and recommends solutions for addressing those bottlenecks.
3. Treatment Process Evaluation Memorandum (APPENDIX C): This TM evaluated OWRF's existing liquid stream treatment process against current and anticipated regulatory requirements. Deficiencies are identified and recommendations provided to upgrade and optimize processes to meet all current and future regulatory requirements.
4. Biosolids Management Technical Memorandum (APPENDIX D): This TM discusses the design of the OWRF solids handling process and operational and functional deficiencies that prevent OWRF from producing Class A biosolids, as designed, and from effectively capturing and utilizing biogas as an energy source within the facility. Recommendations for addressing these deficiencies are included.
5. Condition Assessment Technical Memorandum (APPENDIX E): This TM assesses the condition of all facility assets and the criticality or risk associated with the failure of each asset. Based on the assessment, assets are recommended for immediate replacement, scheduled replacement, moderate renewal, minor renewal, or for no current action to be taken.

Support systems including odor control and electrical systems are discussed in the technical memoranda listed below:

6. Odor Control Memorandum (APPENDIX F): In this TM, existing facilities were examined for their potential to produce fugitive odors, the existing odor control systems were evaluated, and a recommended plan was developed for odor control and treatment planning.

7. Power Distribution Study (APPENDIX G): In this TM, OWRF's existing power distribution system was evaluated. Because the system is past its expected useful life, recommendations were made regarding how to approach required improvements.

3.2. Existing and Projected Wastewater Flows

Table 3-1 below lists the current OWRF wastewater flows as well as the design flows associated with the 2060 buildout condition. The current data were calculated based on daily flow data from 2017 through 2020 provided by OWRF staff. The design flows from the Sewer Master Plan were used as the buildout flow projections. However, for the purposes of this analysis, the Buildout PHF was adjusted from the 21.6 mgd indicated in the Sewer Master Plan to 31.7 mgd by applying the current peaking factor of 2.35 to the estimated Buildout AAD flow condition. This is discussed in the Hydraulic Capacity Technical Memorandum (TM) included herein as APPENDIX B.

Table 3-1 – Existing and Projected OWRF Influent Wastewater

Parameter	Flow Factor ¹	Flow (mgd)	OWRF Buildout Flow ² (mgd)
AAD	1.00	8.93	13.5
ADMM	1.08	9.62	N/A
PDF	1.52	13.56	N/A
PHF	2.35	21.03 ³	21.6 ⁴ / 31.7 ⁵
Minimum Day Flow	0.54	4.82	N/A
1- Flow factor is the ratio of the subject flow to AAD flow 2- From available design drawings for design year 2060, Buildout condition 3- Current PHF is based on hourly flow rate available from Jan 2014 to August 2018 4- Peak Hour Flow estimate from the 2016 Sewer Master Plan 5- PHF calculated for design year 2060, Buildout condition, using the current peaking factor applied to the AAD condition.			

3.3. Effluent Limits

OWRF's currently permitted effluent limits are displayed in Table 3-2 below. Utah State's Technology Based Phosphorus Effluent Limit (TBPEL) of 1 mg/L total phosphorus (TP) went into effect January 1, 2020. OWRF was able to obtain a variance to this rule. They are currently required to meet an effluent TP limit of 2.5 mg/L and the rule will go into full effect beginning January 1, 2025. The facility is currently unable to meet the 1 mg/L requirement with its biological process and will require a chemical addition (Alum) to meet the limit until a sidestream phosphorus removal process can be implemented. The promulgation of a Total Inorganic Nitrogen (TIN) limit of 10 mg/L is also anticipated. This does not impact OWRF in the near term but has been included in the planning analyses. The facility cannot currently meet

this limit, but upgrades have been recommended (see Phase 4 recommended upgrades) that would allow OWRF to meet the limit when required. See APPENDIX C, Treatment Process Evaluation Memorandum for more details.

Table 3-2 – Current OWRF Effluent Limitations from UPDES Permit #UT0020915

	Rated Effluent Limits				
	Maximum, Monthly Average	Maximum, Weekly Average	Yearly Average	Daily Minimum	Daily Maximum
Total Flow, mgd	13.5	--	--	--	--
BOD ₅ , mg/L	25	35	--	--	--
BOD ₅ , minimum % Removal	85	--	--	--	--
TSS, mg/L	25	35	--	--	--
TSS, minimum % Removal	85	--	--	--	--
Dissolved Oxygen, mg/L	--	--	--	5.5	--
Total Ammonia (as N), mg/L	--	--	--	--	--
Summer (Jul-Sept)	3.0	--	--	--	11.0
Fall (Oct-Dec)	4.0	--	--	--	15.0
Winter (Jan-Mar)	5.0	--	--	--	19.0
Spring (Apr-Jun)	4.0	--	--	--	14.0
<i>E. coli</i> , No./100 mL	126	157	--	--	--
Total Phosphorus, mg/L					
Interim	--	--	2.5	--	--
Final (Effective Jan 1, 2025)	--	--	1.0	--	--
WET, Chronic Biomonitoring	--	--	--	--	IC ₂₅ >92% effluent
Oil & Grease, mg/L	--	--	--	--	10.0
pH, Standard Units	--	--	--	6.5	9

3.3.1. Current and Projected Waste Loads

Based on current and projected service populations and facility performance data for the years 2017 through 2020, OWRF's current and future loads were estimated, and are summarized in Table 3-3 below. See APPENDIX A, Flows and Loads Technical Memorandum for more information.

Table 3-3 – OWRF Load Summary

Parameter	Current AAD Condition	Current ADMM Condition	OWRF Design Condition / Buildout ¹
BOD load (lbs/day)	16,232	18,859	39,407 ²
TSS load (lbs/day)	16,910	19,958	39,407 ²
Ammonia load (lbs/day)	2,599	2,938	4,504 ³
TP load (lbs/day)	728	837	N/A
BOD concentration (mg/L)	218	261	350
TSS concentration (mg/L)	227	276	350
Ammonia concentration (mg/L)	34.9	40.6	40.0
TP concentration (mg/L)	9.8	11.6	N/A
TKN _{calculated} concentration (mg/L)	43.6	50.8	50.0
Per capita BOD ₅ contribution ⁴ (lbs/capita/day)	0.15 ⁴	0.17 ⁴	0.30 ⁵
Per capita TSS contribution ⁴ (lbs/capita/day)	0.15 ⁴	0.18 ⁴	0.30 ⁵
Per capita NH ₃ contribution ⁴ (lbs/capita/day)	0.023 ⁴	0.026 ⁴	0.035 ⁵
Per capita TP contribution ⁴ (lbs/capita/day)	0.007 ⁴	0.008 ⁴	N/A
Per capita TKN _{calculated} contribution ⁴ (lbs/capita/day)	0.029 ⁴	0.033 ⁴	0.043 ⁵
1- From available design drawings for design year 2060, Buildout condition 2- Based on design flow of 13.5 mgd and design concentration of 350 mg/L 3- Based on design flow of 13.5 mgd and design concentration of 40 mg/L 4- Service population of 111,000, per City of Orem 2021 Sewer Master Plan. 5- Using design population of 129,900 in year 2060			

4. Environmental Review

Because the facility has been in continuous operation since 1957, the extents of OWRF's environmental impacts are well understood. Furthermore, the discharge loadings to receiving waters are expected to be improved as processes are upgraded to produce a higher quality effluent.

In addition, a tertiary polishing process is currently under construction, which will treat up to half of the facility's effluent to allow the water to be reused for irrigation at Sleepy Ridge Golf Course and at Lakeside Sports Complex. This will reduce loadings to receiving waters during the summer months. In the winter months, the high quality tertiary effluent will be blended with water from the secondary process reducing overall loadings to receiving waters

4.1. Flood Plains and Seismic Risk

Orem City is partially impacted by 100- and 500-year flood plains. OWRF is adjacent to but not within impacted areas of the City. Figure 4-1 is the FEMA flood plain map for Orem City, on which the OWRF site has been overlaid to show the extent of the floodplains and their vicinity to OWRF.

The City is located in a seismically active area, situated about four miles from the Wasatch Front fault line. Figure 4-2 shows the liquefaction potential for the State of Utah, which is greatest in the areas surrounding Utah Lake, such as Orem City. The location of the OWRF is indicated on this map for reference. It is worth noting that the areas surrounding Utah Lake, in which OWRF is situated, are at high risk of liquefaction during a seismic event. A geotechnical analysis including development of a site ground improvements plan is critical to constructing adequate structural support for all new facilities. Geotechnical analysis will be necessary as a site plan is developed and prior to construction to avoid significant settling of facilities in the event of a seismic event that results in liquefaction.



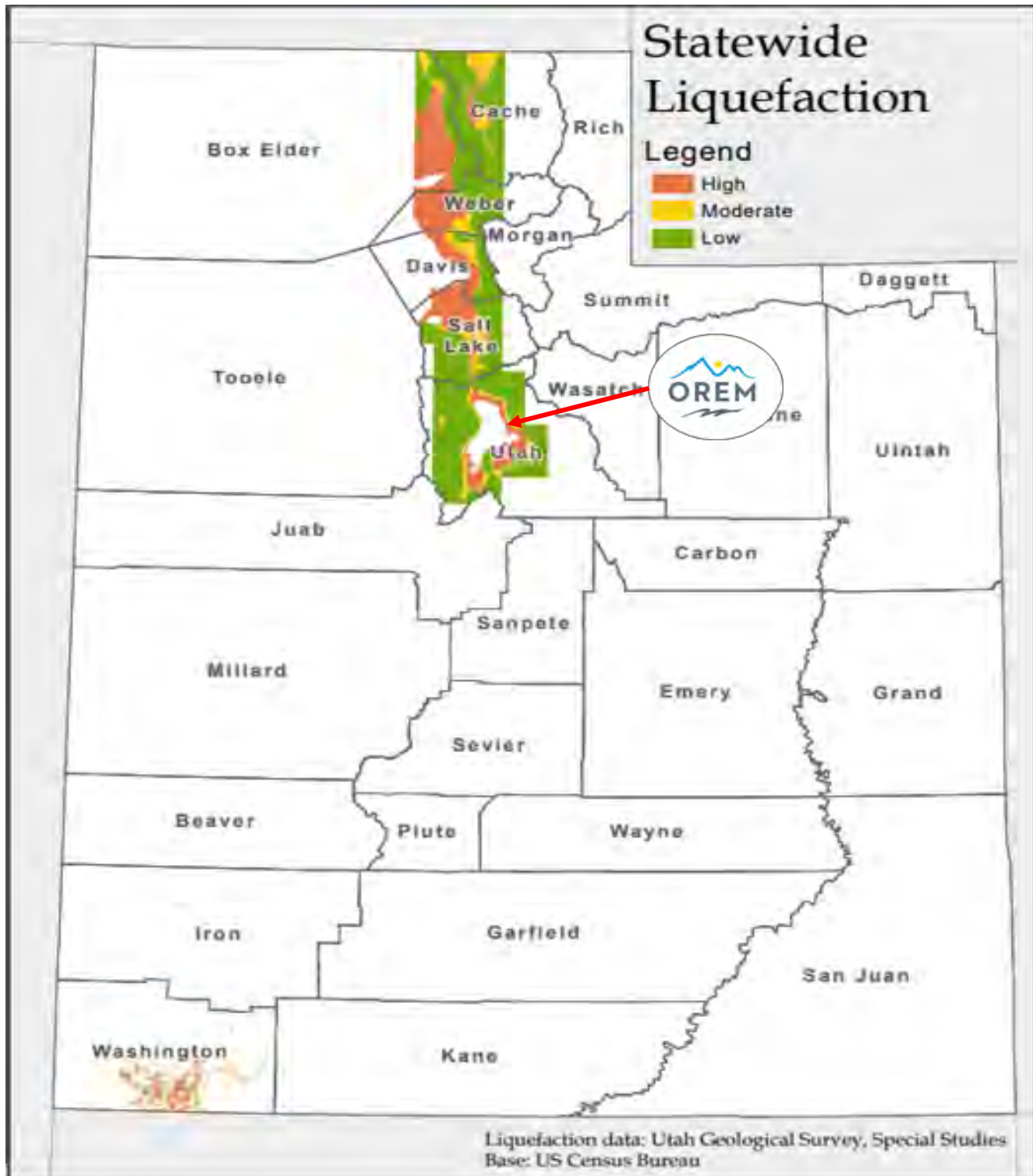


Figure 4-2 – Liquefaction Hazard map for OWRF

4.2. Air Quality and Odor Control

Historically, OWRF has had few municipal odor complaints. In fact, there have been only three such complaints in the last four years. OWRF staff have suggested that even these may be erroneous. The prevailing winds are more frequently in a Southeasterly direction than in a Northwesterly direction, suggesting that the odors may be carried from Utah Lake to neighboring residences rather than from the OWRF. See APPENDIX F Odor Control Memorandum for more details.



[PVU] PROVO MUNI (AWOS)
Windrose Plot [Time Domain: Jan 1 - Dec 31, 12 AM-11 PM]
Time Bounds: 01 Jan 2017 12:56 AM - 31 Dec 2020 10:56 PM America/Denver

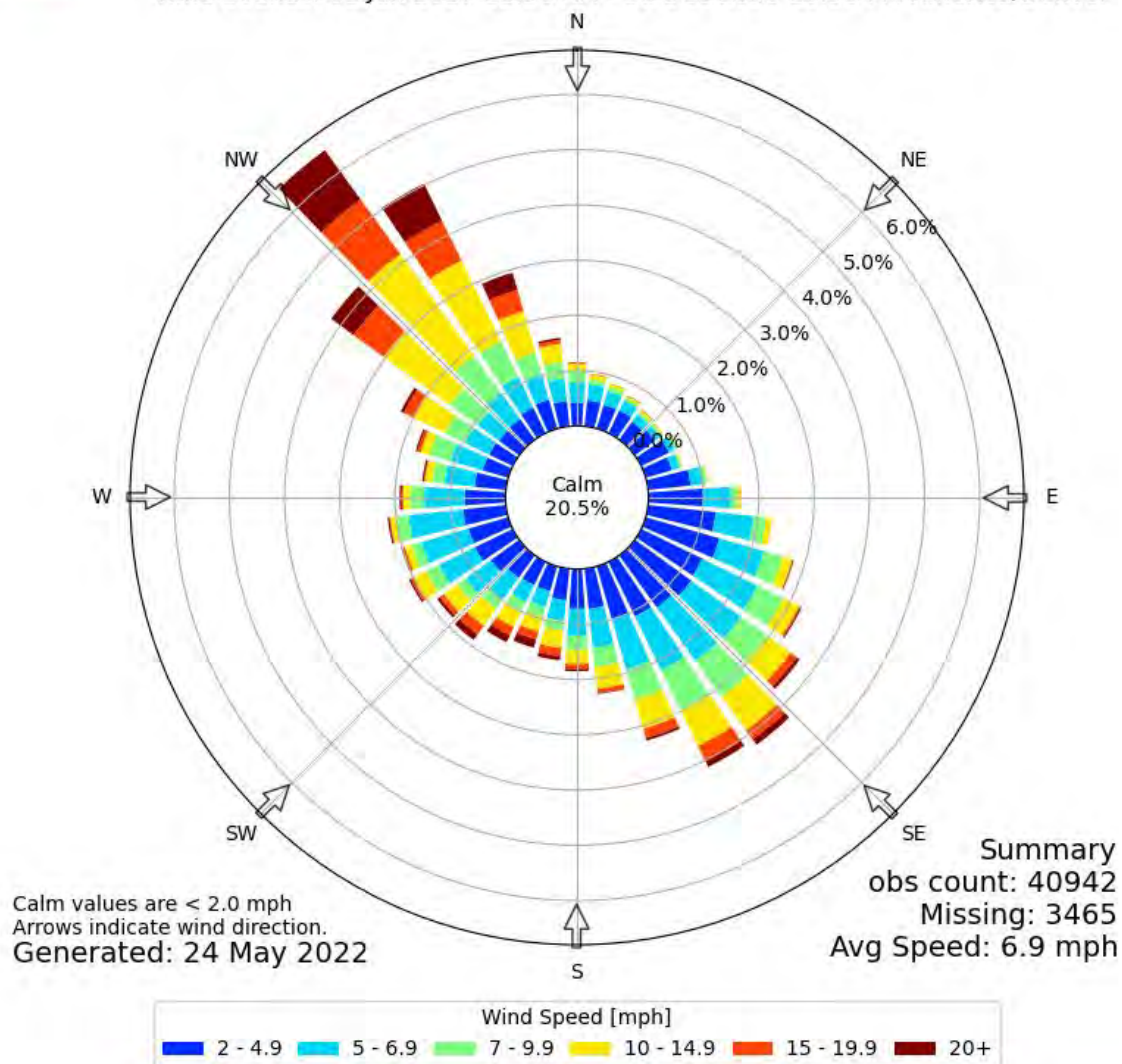


Figure 4-3 – Wind Rose at Provo Municipal Airport from January 2017 to December 2020

Although the facility has experienced few complaints regarding fugitive odors, there are OWRF processes that produce nuisance odors within the boundaries of the facility that need to be addressed. These include:

1. The Headworks Building does not have any odor containment or treatment systems and is a major source of odors.
2. The primary treatment process is not a significant source of nuisance odors, but may benefit from covers over launders and weirs, where turbulent water results in intermittent odors.
3. The solids handling process is a major source of odors. The biosolids building has two odor control units, which have reached the end of their useful life, and the thermophilic digester building has one odor control unit that is outdated and undersized for the application.

5. Performance and Condition Assessment Summary Review by Process Area

Process modeling was performed for the full liquid and solid stream processes at OWRF, and is discussed in APPENDIX C, Treatment Process Evaluation Memorandum and APPENDIX D, Biosolids Management Technical Memorandum. As the facility is currently operated, it is unable to achieve the level of solids thickening assumed for the design condition. Dilute solids loading creates high hydraulic loadings at the thermophilic and mesophilic digesters and makes it impossible to achieve the design SRTs of 6 days and 8 days, respectively, as the operating point approaches the buildout condition. This is shown in Table 5-1, which documents the process performance without thickening. This will inhibit OWRF's ability to achieve production of Class A and Class B biosolids. Dilute loading to the digesters also results in acidic conditions, which limits the facility's ability to produce and recapture methane gas to power processes, reducing overall energy efficiency. It also results in incomplete digestion of organic material. Although this improves biological phosphorus and nitrogen removal at the secondary process due to increased recirculation of short-chain organics that are more readily used as a food source for microbial processes, it creates an unstable digestion process, more prone to upset and with the potential to create significant odors.

Table 5-1 – Predicted Treatment Process Performance at Design Flow and ADMM Load

Parameter	Model Value
Influent Flow (mgd)	13.5
Influent BOD (mg/L)	261
Influent TSS (mg/L)	276
Influent TKN (mg/L)	50.80
Influent NH ₃ -N (mg/L)	40.6
Influent TP (mg/L)	6.8
Influent pH	7.5

Parameter	Model Value	
	Winter Month Model	Summer Month Model
Temperature (°C)	13.5	23.1
Bioreactor SRT (days)	18.6	18.6
Bioreactor Average MLSS (mg/L)	3,650	3,437
RAS Flow Rate (mgd)	13.2	13.2
WAS Flow Rate (mgd)	0.26	0.26
Thermophilic Digester SRT (days)	4.6	4.6
Mesophilic Digester SRT (days)	3.2	3.2
Aluminum Sulfate Dose (gal/day)	550	750
Belt Filter Press Filtrate TP (mg/L)	53.2	27.4
Effluent BOD (mg/L)	3.7	3.4
Effluent TSS (mg/L)	7.3	6.9
Effluent NH ₃ -N (mg/L)	2.2	0.72
Effluent TIN (mg/L)	3.9	1.46
Effluent TP (mg/L)	0.41	0.44

The facility is unable to thicken primary sludge and WAS to the design solids concentration because the existing primary sludge and WAS pumps do not provide adequate suction lift when solids streams are thickened to the design concentration. This results in excessive hydraulic loading to the solids stream process compared to the design condition. As a result, the primary sludge pumps, WAS pumps, thermophilic equalization basin pumps, mesophilic and thermophilic digester feed pumps, boiler system pumps, and dewatering feed pumps are undersized for current and buildout operation. The digestion process is not as effective and the dewatering process, in turn, is not as effective. This can affect polymer usage and hauling costs incurred by the facility.

OWRF currently lacks the ability to reliably control how RAS is split among its secondary process bioreactors. The aerobic zones of its BNR bioreactors operate at a high DO setpoint. This may inhibit the facility's ability to optimize nutrient removal. A high DO setpoint in the aerobic zones may also result in high nitrates levels being returned to the anaerobic zones, preventing the conditioning of PAOs for phosphorus removal. It also results in an increased energy cost associated with over-aeration. Uneven RAS flow split to the bioreactors can affect MLSS concentrations and SRTs in the bioreactors, which can affect the overall ability to treat for BOD and nutrient removal. Inefficient biological phosphorus removal may result in an increased chemical dosing requirement to meet effluent limits. Increased chemical dosing represents and increased cost of operations.

OWRF's headworks, primary effluent pump station, bioreactors, digestion processes, and ultraviolet disinfection (UV) facility lack sufficient redundancy. This lack of redundancy is discussed in detail in APPENDIX B, Hydraulic Capacity Technical Memorandum, and APPENDIX D, Biosolids Management Technical Memorandum, and means that if a unit were to fail, or if it had to be taken offline for

maintenance or repair, the process would lose its ability to operate as designed, potentially affecting the facility's ability to meet effluent limits, and in the case of the biosolids handling processes, to produce Class A or Class B Biosolids. Class A and Class B biosolids may be used for land application as a fertilizer for non-food crops and animal food crops. If OWRF loses the ability to produce these biosolids, the facility will incur increased landfill fees.

Odor control is not only an aesthetic feature for a facility. Gases that cause unpleasant odors, such as Hydrogen Sulfide and Ammonia can be toxic, corrosive, and can create explosive environments. Odor control can reduce the toxicity and corrosiveness in facilities by containing and removing hazardous gases. In addition to odors and toxicity, current NFPA 820 guidelines classify headworks, primary treatment, biosolids handling, and other facilities as hazardous, requiring that intrinsically safe and explosion-proof equipment, instruments, and electrical systems are used. Most of these structures at OWRF were constructed in the 1980s or earlier, meaning that their construction pre-dates the current requirements for area classification. This is a potentially life-threatening safety concern.

In general, the OWRF electrical system has been well maintained, and is in fair condition. However, much of the facility's existing electrical system has reached the limit of its expected useful life, and replacement parts for repairs are becoming increasingly difficult to find. Equipment described as undersized or in poor condition in APPENDIX E, Condition Assessment Technical Memorandum, and APPENDIX G, Power Distribution Study prevent or impede the proper operation of processes. Equipment described as in good condition may be monitored until signs of failure are detected. It is worth noting, however, that in the current marketplace, procurement of electrical equipment is difficult. Equipment carries extremely long lead times. Waiting until equipment has failed to replace it is not advised.

Many facilities on site at OWRF, particularly those built in the 1980s and earlier, do not meet current seismic requirements of the International Building Code (IBC). As previously discussed, this is of particular concern for a facility in close proximity to the Wasatch Fault Line and in an area with a high liquefaction potential.

6. Development of Alternatives

The deficiencies listed above and in the technical memoranda were used to develop improvements at the OWRF as described in the following subsections. The service area is projected to grow and expand as detailed in Section 1 and Section 3. Key drivers for recommended upgrades include:

1. Optimization: Process optimization will allow the facility to meet buildout conditions as regulatory changes to effluent nutrient limits evolve as anticipated. This optimization will allow OWRF to operate at capacity through buildout, as designed.
2. Redundancy: Providing sufficient system redundancy will allow the facility to meet all effluent requirements, even in the event of equipment failure or scheduled maintenance. Statutory requirements for redundancy of electrical systems and critical processes are detailed in Utah Administrative Code Rule r317-005.

3. Updating: Aging facilities require upgrades or replacement to promote safety, process efficiency, and to provide adequate working space. Many facilities need to be upgraded or rebuilt to address structural concerns related to seismic vulnerability. The electrical systems in various facilities need to be upgraded or rebuilt to address area classification requirements of NFPA 820.

These and other requirements will be addressed by facility in the following subsection.

6.1. No Action

The *No Action* alternative involves making no efforts to replace, upgrade, and expand operations at the current facility, with the exception of ordinary repairs and maintenance necessary for continued operation. It is important to discuss potential consequences of not taking any action so that the need or lack of need for upgrades is well understood.

Based on the deficiencies discussed above, a No Action alternative is not advisable. As OWRF is currently operated, it does not meet the process requirements it was designed to, and aging facilities which are not up to current building codes are costly and represent a significant safety concern. Aging processes that lack sufficient redundancy threaten to limit the treatment capabilities of the OWRF if repair or maintenance is required. These deficiencies will become more pronounced as the buildout condition is approached. The following section details recommended upgrades to the facility.

6.2. Wastewater Management Techniques

Managing the development of the OWRF in the most cost-effective manner considering treatment goals and community growth is integral to the project. Selecting technologies involves evaluation of conventional, alternative and innovative technologies. Consideration of current and future community goals leads to projects that serve multiple purposes for the community. Selection of a path forward involves careful consideration of the most advantageous project implementation phasing plan. These topics are discussed in the following sections.

6.2.1. Conventional Technologies

Conventional treatment technologies are well understood and proven methods for reliable systems. These technologies are often the most economical in terms of capital cost, annual costs, and operability. For these reasons, the use of conventional technologies is considered, and usually preferred for treatment of typical wastewater constituents. Examples of conventional treatment technologies include conventional activated sludge (CAS). With the promulgation of the TBPEL rule in 2020 and anticipated future limits that may be placed on total inorganic nitrogen (TIN) and total nitrogen (TN), it becomes increasingly difficult to meet regulatory requirements using a CAS system without chemical addition. Biological nutrient removal is generally preferred because it is more cost effective, and not subject to market fluctuations. Alternative technologies or system modifications may then be required to meet effluent limits and treatment goals.

6.2.2. Alternative Technologies

Alternatives to CAS technology are typically considered when wastewater constituent profiles are unusual or when regulatory changes reduce the effectiveness of conventional technology to meet permit limits, especially when site footprint is limited. Alternative technologies typically require greater capital expenditure than conventional technologies but may offer a more cost-effective approach overall, based on a facility's unique goals. Alternatives to CAS technology may include biological nutrient removal (BNR), or processes that rely on higher mix liquor concentrations such as activated granular sludge (AGS), Mobile Organic Biofilm (MOB) and membrane bioreactor (MBR). OWRF retrofitted its oxidation ditches with BNR capabilities in 2010 to promote nutrient removal. OWRF requires only minor process improvements to meet its current treatment goals at community buildout and therefore does not need to consider alternative processes. Requirements to meet potential TIN limitations are discussed in the Phase 4 recommended upgrades.

Carbon limitation and over-aeration of the BNR aerobic zones have been identified as areas in which process optimization is required. These are discussed briefly in the following sections, and in detail in APPENDIX C, Treatment Process Evaluation Memorandum.

6.2.2.1. Ammonia Based Aeration Control (ABAC)

ABAC uses feedback from ammonia probes placed at the upstream and downstream ends of the aeration zones of the BNR bioreactor to control aeration, supplying only what is needed to meet permitted limits. This will reduce dissolved oxygen, nitrates, and nitrites in the RAS, preventing poisoning of the anaerobic basins. OWRF has already obtained ammonia probes to implement ABAC.

6.2.2.2. Partial Bypass of Primary Influent to Bioreactors

Because OWRF is carbon limited, conserving carbon in the liquid stream acts as a critical food source for microbial activity. The bypass will send primary influent directly to the bioreactors (and sidestream phosphorus removal processes discussed in the following section) to supplement carbon required for biological phosphorous removal and denitrification. This will promote increased solids production in the secondary treatment process and allow the solids stream treatment process to operate at capacity.

6.2.2.3. Chemical Addition

OWRF may also use chemical addition to promote the removal of phosphorus to meet regulatory effluent limits. As previously discussed, biological treatment is generally preferred. However, chemical addition is capable of producing a lower effluent phosphorus than biological treatment, which may be required if the total phosphorus effluent limit is decreased by future regulatory requirements. One drawback of using chemical addition for phosphorus removal is that phosphorus bound by chemical precipitation is no longer bioavailable in land applied biosolids.

6.2.3. Sidestream Treatment

As OWRF begins to optimize its solids conveyance process by improving thickening and performance of the digestion process, removal of nutrients in the liquid stream will decrease due to lower available

carbon being returned from solids stream processes (see APPENDIX D, Paragraph 6.1 and Table 6-1 for details). Table 6-1 below shows the process performance with additional thickening as opposed to the process performance documented in Table 5-1 without adequate thickening.

Innovative treatment technologies recommended for OWRF include processes used for sidestream phosphorus removal. With the promulgation of the 2020 TBPEL rule, sidestream phosphorus removal is becoming increasingly common. These processes sequester phosphorus to the solids stream for removal with the biosolids. These processes keep phosphorus in bioavailable forms. In land applied biosolids this may act as an additional fertilizer. The technologies described in the following sections are potential processes that could be used at OWRF.

Table 6-1 – Predicted Process Performance at Design Flow / ADMM Load with Biosolids Thickening

Parameter	Model Value	
Influent Flow (mgd)	13.5	
Influent BOD (mg/L)	261	
Influent TSS (mg/L)	276	
Influent TKN (mg/L)	50.8	
Influent NH ₃ -N (mg/L)	40.6	
Influent TP (mg/L)	6.8	
Influent pH	7.5	
	Winter Month Model	Summer Month Model
Temperature (°C)	13.5	23.1
SRT (days)	17.4	17.4
Bioreactor Average MLSS (mg/L)	2289	2328
RAS Flow Rate (mgd)	9.9	9.9
WAS Flow Rate (mgd)	0.24	0.24
Thermophilic Digester SRT (days)	9.1	9.1
Mesophilic Digester SRT (days)	12.6	12.6
Aluminum Sulfate Dose (gal/day)	600	750
Belt Filter Press Filtrate TP (mg/L)	88.5	85.7
Effluent BOD (mg/L)	2.1	2.1
Effluent TSS (mg/L)	4.0	4.1
Effluent NH ₃ -N (mg/L)	0.73	0.44
Effluent TIN (mg/L)	10.6	3.81
Effluent TP (mg/L)	2.4	1.5

6.2.3.1. Post Aerobic Digestion (PAD)

Post aerobic digestion (PAD) is one technology that is recommended for sidestream phosphorus removal. As the name of the process suggests, it is an aerobic digestion process that follows anaerobic digestion.

The advantages of PAD are that it further reduces the mass of solids in anaerobically digested sludge, further stabilizes the sludge, reduces odors, and aids in the production of Class A biosolids. It also removes a significant amount of the ammonia from the digested solids, which will reduce the high-concentration slug loadings of ammonia at the headworks. PAD has also shown some potential for reducing the phosphorus concentration in the digested solids, decreasing the potential to form struvite in downstream piping and equipment, and reducing the phosphate concentration in the return stream. A disadvantage of PAD is that the process generates heat that must be removed to maintain stable operation. The heat is of poor quality and not effective for energy production. OWRF has two aerobic digesters that are currently used as solids holding tanks. However, these lack sufficient capacity for a PAD system and additional tankage would be required.

The performance of PAD systems in removing phosphorus has not been consistent across the various PAD installations, so pilot testing will be required to reliably predict the system's performance. Inconsistent phosphorus removal is possibly associated with the heat generated by the process, or by fluctuations in pH, but the reason for the variability in performance is not yet well understood. PAD is a relatively new process. New technologies often require development time for process optimization. Implementation of a technology before its use is proven and well-understood carries inherent risks.

6.2.3.2. Biosolids Aeration

Biosolids aeration systems, such as the MagPrex system manufactured by Centrisys, is a proven method of sequestering phosphates (as Struvite) to the solid phase for removal and disposal or recovery. The process utilizes aeration to drive off carbon dioxide gas from digested solids, increasing system pH and promoting conditions favorable to the formation of struvite. Maximizing struvite formation during this process minimizes the potential for struvite scaling in downstream processes where operations may be impaired by scale and equipment may be damaged. The process may be optimized for phosphorus removal by adding magnesium to the system. Magnesium is often the limiting factor in struvite formation, so magnesium addition (usually magnesium chloride, $MgCl_2$) is typically required to sufficiently reduce phosphorus concentrations to support EBPR.

In addition to minimizing downstream struvite formation and reducing the phosphorus concentration, biosolids aeration improves the effectiveness of dewatering efforts, reducing the polymer dosing requirement. Furthermore, by promoting struvite formation in the biosolids, phosphates are sequestered to the solid phase for removal rather than being cycled back to the headworks with the pressate. The process can also be modified for phosphate recovery if a local market for phosphorus resale is developed.

This process has a limited effectiveness in the reduction of ammonia in the solids stream. Though some ammonia stripping occurs during aeration, and struvite formation consumes some ammonia, these mechanisms are not sufficient to significantly reduce the high concentration of ammonia in the digested solids. Therefore, if the process is selected, equalization for the return pressate stream, or another process, may be required to reduce ammonia in the return stream.

6.2.3.3. Vacuum Degassing of Biosolids

Vacuum degassing systems, such as the Elovac system manufactured by Ovivo, are similar in function to biosolids aeration, except that instead of using air to drive carbon dioxide and raise pH, vacuum pressure is used. The major advantage of the Elovac system is that its installation footprint is much smaller than biosolids aeration systems. This is a relatively new treatment technology, with only one domestic Installation at the Provo Water Advanced Treatment and Resource Recovery (WATRR) Center. However, Provo has had success running the system, and has a similar wastewater profile to Orem City's. OWRF is currently in the process of procuring piloting estimates for a vacuum degassing system.

6.3. Recommended Upgrades to the Existing OWRF Facility

Based on the analysis of the OWRF described above and detailed in each of the technical memoranda attached to this document in APPENDIXES A through G, the recommended upgrades and repairs are listed by facility in Table 6-2 below.

Table 6-2 – Recommended OWRF facility Upgrades by Process

Liquid and Solids Stream Processes and Facilities	
Headworks	
● Replace Entire Facility, addressing: 1) Code deficiencies 2) Aging equipment and facilities 3) Lack of redundancy 4) Hydraulic bottlenecks 5) Aging electrical equipment 6) Odor Control	
Grit Basin and Grit Blower Building	
● Update air lift system, valves, and piping ● Replace grit blower building ● Replace grit air diffusers ● Upgrade facility to meet NFPA 820 requirements for area classification ● Add redundant grit basin ● Install odor control	
Primary Clarifiers	
● Structural repairs as needed ● Add weir covers for odor control ● Upgrade facility to meet NFPA 820 requirements for area classification	

Primary Sludge Pump Building
• Replace structure and building for code compliance • Upgrade pumps to a type/model capable of pumping sludge with 3% solids
Primary Effluent Pump Stations
• Demo screw pumps and structure • Expand mixed flow pump station to meet buildout capacity with redundancy
Oxidation Ditch Upgrades
• Process instrumentation: Ammonia probes for ABAC have been purchased by OWRF. WaterWorks to recommend installation locations • Replace and improve aeration piping • Concrete Repairs
Bioreactors
• Demo surface aerators and install new aeration system with motorized valves for flow control • Add a blower for redundancy • Replace mixers with a mechanical mixing system • Install a standby bioreactor • Additional volume for denitrification • Replace generator and automatic transfer switch in the BNR Blower Building
Secondary Clarifiers
• Replace Clarifier No. 5 and 6 mechanisms • Replace Clarifier No. 7 and No. 8 weir gates • Clarifier No. 7 flow meter • Clarifier No. 7 and No. 8 differential level meters • Clarifier No. 7 scum slide gate
RAS/WAS and Generator Building
• Replace RAS/WAS building addressing: 1) Code deficiencies 2) Aging facilities and electrical equipment • Replace RAS flow meters • Replace WAS flow meter • Replace RAS and WAS flow control • Upgrade WAS pumps to a type/model capable of pumping sludge with 1% solids to the Thermophilic Equalization tank. • Upgrades to HVAC system and Louvers
UV system
• Construct a third UV channel and expand existing UV control system and facility to meet redundancy requirements through buildout. • Replace UV bulbs • Install a screen upstream of UV system for removal of debris • Add a weir gate to control WSE in UV channels • Replace existing flume with 36" flume for buildout flow measurement • Replace influent / effluent gates and actuators

Thickening
● Refurbish DAF thickener for current operations to be capable of thickening to 3% solids as designed ○ Replace DAF thickener mechanism and Motor ○ Replace diaphragm sludge pumps and starter panel ○ Replace VFDs and disconnects on recirculation pumps ○ Replace DAF PLC and control panels for DAF, diaphragm pumps, and air entrainment tank ● Construct a new WAS thickening building to address redundancy and code deficiencies ○ Update electrical system ○ Provide odor control facility
Thermophilic Digester
● Construct a redundant digester with associated equipment (Hot Water Boiler, Hot Water System, Mixing Equipment) ● Equip system for use as a thermophilic or mesophilic digester to add system redundancy when a digester is taken offline for repairs / maintenance so Class A biosolids can be produced even with one digester offline ● Address code deficiencies ● Install an odor control system with all appurtenances ● Replace primary digester cover and ancillary equipment
Mesophilic Digester
● Replace secondary digester building ancillary equipment ● Add a dedicated redundant mesophilic digester ● Replace primary digester mixer ● Replace heat exchangers ● Replace flow meters ● Upgrade existing mesophilic digester related pumping equipment to allow for pumping of 3% solids feed to digesters.
Flare Building
● Add Redundant Flare stack
Biosolids Building / Dewatering
● Replace Belt Filter Presses with Screw Presses ● Expand facility to accommodate installation of up to five screw presses for expanded capacity
Sidestream Treatment
● Add an Elovac System - Sidestream biological phosphorus removal will be required to promote removal of phosphorus with the biosolids.
Sludge Holding Tanks
● Install an odor control System with all appurtenances ● Install a sludge grinder
Impure Pump Building

This facility is required only until the current reuse project is complete. Repair pumps as necessary until facility is decommissioned
Maintenance Shop Building
- Replace structure addressing: - Code deficiencies - Aging facilities - Better works space
Other
Install a weather station on site for odor complaint tracking
Power Distribution Study
Correct Deficiencies
- Correct deficiencies identified in the OWRF power system study, Project # 374-19-01, September 21, 2021, produced by Bower Collins & Associates - Upgrade all facilities to meet NFPA 820 area classification requirements - Upgrade the following equipment that is in poor condition: MCC-4, MCC-AD, Chlorine building electrical panels, DAF Building electrical panels and DAF starter panel, RAS/WAS electrical switchgear, MCC3, MCC5, and miscellaneous electrical devices
Expand Capacity
- Utility primary metering - Medium-voltage distribution
Enhance reliability
- Provide a central generator system to supply the entire facility - Provide dual feeders to each distribution transformer to eliminate single points of failure - Provide a portable generator tap box to allow a second source to connect to each service to eliminate single points of failure
Power Monitoring
Provide metering in each service and motor control center and connect to the SCADA system to monitor the power demand. Some equipment has metering installed presently

6.4. Staged Construction and Capital Finance Planning

Staged construction is typically employed to balance project needs with available funds. Single phase construction often results in lower overall costs by consolidating contractor mobilizations. Sunk costs may also be reduced by limiting costs associated with the following items:

- Construction of temporary facilities that will be decommissioned during future phases
- Temporary connection of new facilities to existing facilities that will be decommissioned during future phases
- Repairs and upgrades necessary for the continued use of existing facilities that are ultimately intended for replacement
- Diminished ability to improve flow pathways and hydraulics due to constraints introduced by designing processes to operate with both existing process facilities and their future replacements

Some of these challenges may be overcome with careful planning. Despite these challenges, staged construction is often preferred as it reduces the immediate capital expenditures. The financial resources needed for a project may require time to develop and some upgrades are more urgent. Staging also allows the financial burden that is passed on to the system's users to be applied more gradually if rates are used to pay for improvements. Finally, staged construction also maintains the facility's continued operation by bringing new system processes online at different times and allowing their operation to be optimized with minimal interruption to operations.

Estimated costs associated with all recommended upgrades are shown in Table 6-3 to aid the City with planning of capital expenditures and balancing that with OWRF needs with respect to optimizing processes and repairing/upgrading/replacing equipment and facilities in a timely manner. Figure 6-1, Figure 6-2, Figure 6-3, and Figure 6-4 are site layouts showing where and when upgrades are recommended.

The total cost of all recommended upgrades is estimated to be approximately \$160M.

The Phase 1 recommended upgrades total approximately \$58M and address all issues that must be addressed in the near term to allow the OWRF to operate as designed. It is recommended that these upgrades be completed within the next 5 years.

- 1) Grit removal system: Upgrades are recommended to add redundancy, replace aging equipment, comply with area classification requirements, and provide odor control.
- 2) Primary Clarifiers: Minor repairs and upgrades to the primary clarifiers as needed for continued operation.
- 3) Primary Effluent / Screw Pump Station: It is recommended that OWRF replace its existing screw pump station with a facility that expands the vertical/mixed flow pump capacity for redundancy and buildout flows.
- 4) Primary Sludge Pump Station: The pumps in this facility are not capable of pumping thickened sludge as designed and are to be replaced with pumps that have this capability.
- 5) Secondary Clarifiers: Clarifiers No. 5 & 6 are recommended for replacement of their mechanisms, and No. 7 & 8 for replacement of their weir gates and instruments.
- 6) Bioreactors: OWRF Bioreactors, BNR No. 1 and BNR No. 2 are to be upgraded with ABAC capability including a new aeration system with motorized valve for aeration control and ammonia probes installed at the aerated zones of the bioreactors. The bioreactor's mixing system is to be replaced with a mechanical mixing system. The bioreactor structure shall be repaired as needed to prevent leakage, and additional bioreactor volume shall be added to accomplish nitrification.
- 7) Disinfection upgrades: Expansion of the disinfection process is required for redundancy. The UV bulbs currently installed are due for replacement. An upstream screen to prevent debris in the channel is recommended to reduce head losses. The effluent flume is not rated for the full range of buildout flows, and the influent and effluent gates and actuators are to be replaced.
- 8) DAF Thickener: Upgrades to the existing DAF Thickener are required to address operational issues and allow operators to thicken solids to the design solids concentration. Upgrades shall include

replacement of the mechanism, sludge pumps, starter panel, VFDs, recirculation pumps, and PLC, and control panels.

- 9) Digestion Process: . Mesophilic secondary digester cover is to be replaced. Digester ancillary equipment, such as boilers and flame trap assemblies are to be upgraded. A new redundant biogas flare is to be installed
- 10) Biosolids Building and Dewatering Process: Belt Filter Presses are to be replaced with Screw Presses for improved dewatering performance. Building is to be updated as necessary to meet current building and NFPA 820 codes.
- 11) Sidestream Phosphorus Removal: To promote the removal of phosphorus with the biosolids, installation of a sidestream phosphorus removal and struvite mitigation system is recommended.
- 12) Integration and programming of processes will be a part of all process upgrades.
- 13) Replace existing maintenance building to address aging structure and code requirements.
- 14) Odor Control: New odor control systems are to be constructed for the headworks and solids handling processes. These upgrades will be undertaken over the next 1-10 years.

Some of the recommended upgrades are already being investigated. In fact, OWRF is in the process of implementing some, such as procurement of a sidestream phosphorus removal system and the addition of ammonia probes to the bioreactors for the implementation of ammonia based aeration control.

The Phase 2 recommended upgrades total approximately \$40M and include upgrades to equipment and facilities that are in adequate condition but carry a high risk of failure, and continued upgrades required to bring facilities up to building and safety codes. These upgrades are recommended within the next 5-10 years and include:

- 1) Headworks: Full replacement of the Headworks is recommended to address aging equipment and structures, building code and NFPA 820 area classification requirements, add redundancy and incorporate odor control.
- 2) RAS/WAS Pump Station and Generator Building: Full replacement of the structure is recommended, addressing an aging system with an inadequate HVAC system, and code deficiencies. In addition, the RAS and WAS flow meters and flow control system need to be replaced with one that allows operational control, monitoring, and flexibility.
- 3) DAF: Full replacement of the WAS thickening system will be required within the next 5-10 years. OWRF staff have requested an evaluation of available WAS thickening technologies before a technology selection is made.
- 4) Digestion Process: A new thermophilic digester is required for redundancy. It is recommended that this digester be equipped to act as a swing digester (either thermophilic or mesophilic) to provide redundancy and operational flexibility in both the thermophilic and mesophilic digestion processes. The primary mesophilic digester's cover is to be replaced.
- 5) Installation of tankage for pressate equalization: Pressate equalization allows operators to equalize return flows from the sludge handling and dewatering processes as they are recirculated to the headworks for treatment. Equalization promotes process stability by reducing slug

loadings of ammonia, phosphorus, and other constituents in return waste streams to the headworks.

- 6) Odor Control: New odor control systems are to be constructed for the headworks and solids handling processes. These upgrades will continue from Phase 1 through the end of Phase 2.
- 7) Upgrades to the site electrical and power distribution system.

The Phase 3 recommended upgrades total approximately \$25M and include facilities that are currently in good condition and at low risk of failure. These facilities are planned for replacement in the next 10-15 years and include:

- 1) Grit removal system: Upgrades are recommended to this process in the Phase 1 repairs. Once those upgrades are completed, the existing system will likely provide another 5-10 years of useful, but it is an aging system that will need to be fully replaced.
- 2) Renewable Natural Gas: This equipment will scrub biogas produced by the solids handling process for use to power the OWRF, to be piped and sold to the local utility, or to fuel a portion of the City's fleet. These systems typically pay for themselves within a few years in the form of mitigated energy expenditures or by generating a revenue stream on biogas that is sold to the natural gas utility.
- 3) Replacement of the impure water building if required: This facility may not be required after the facility's reuse project is complete
- 4) Grading, Paving and Site Drainage upgrades as required.

The Phase 4 recommended upgrades total approximately \$37M. Not all items included in this phase are not strictly required for the proper operation of the facility but would expand redundancy and promote operational flexibility:

- 1) Construction of a third, redundant, bioreactor: A third bioreactor will provide complete redundancy in the facility's secondary process and is preferred by OWRF staff. The bioreactor will allow one bioreactor to be removed from service, as required, for maintenance and repair or for operational flexibility.
- 2) Conversion of the Bioreactors to Plug Flow Reactors to improve the secondary process and prevent treatment short circuiting.
- 3) Installation of a redundant mesophilic digester.

Table 6-3– OWRF - Facility Plan Cost Estimate and Phasing plan

OWRF - Facility Plan Cost Estimate											
Facility No.	Liquid Stream Process	Estimated Cost	Phase 1 (1-5 Years)		Phase 2 (5-10 Years)		Phase 3 (10-15 Years)		Phase 4 (>15 Years)		
1	Headworks	\$ 12,029,000	No	\$ -	Yes	\$ 12,029,000	No	\$ -	No	\$ -	
2	Grit Improvements	\$ 1,671,000	Yes	\$ 1,671,000	No	\$ -	No	\$ -	No	\$ -	
3	New Grit	\$ 10,726,000	No	\$ -	No	\$ -	Yes	\$ 10,726,000	No	\$ -	
4	Primary Clarifiers	\$ 103,000	Yes	\$ 103,000	No	\$ -	No	\$ -	No	\$ -	
5	Primary Effluent/Mixed Flow Pump Station	\$ 2,193,000	Yes	\$ 2,193,000	No	\$ -	No	\$ -	No	\$ -	
6	Primary Sludge Pump Station	\$ 2,410,000	Yes	\$ 2,410,000	No	\$ -	No	\$ -	No	\$ -	
7	Oxidation Ditch Improvements	\$ 6,599,000	Yes	\$ 6,599,000	No	\$ -	No	\$ -	No	\$ -	
8	Bioreactors	\$ 16,071,000	No	\$ -	No	\$ -	No	\$ -	Yes	\$ 16,071,000	
9	Redundant Bioreactor	\$ 16,000,000	No	\$ -	No	\$ -	No	\$ -	Yes	\$ 16,000,000	
10	Secondary Clarifiers	\$ 1,753,000	Yes	\$ 1,753,000	No	\$ -	No	\$ -	No	\$ -	
11	RAS/WAS and Generator Building	\$ 3,200,000	No	\$ -	Yes	\$ 3,200,000	No	\$ -	No	\$ -	
12	Disinfection	\$ 9,113,000	Yes	\$ 9,113,000	No	\$ -	No	\$ -	No	\$ -	
13	Odor Control	\$ 3,955,000	Yes	\$ 1,977,500	Yes	\$ 1,977,500	No	\$ -	No	\$ -	
Liquid Stream Total:			\$ 25,819,500		\$ 17,206,500		\$ 10,726,000		\$ 32,071,000		
Solid Stream Process		Estimated Cost									
14	Refurbished DAF	\$ 1,933,000	Yes	\$ 1,933,000	No	\$ -	No	\$ -	No	\$ -	
15	New Thickening Process	\$ 4,759,000	No	\$ -	Yes	\$ 4,759,000	No	\$ -	No	\$ -	
16	Primary Digester Control Building and existing digester cover and ancillary equipment	\$ 5,824,000	Yes	\$ 5,824,000	No	\$ -	No	\$ -	No	\$ -	
17	Thermophilic Digester	\$ 11,707,000	No	\$ -	Yes	\$ 11,707,000	No	\$ -	No	\$ -	
18	Mesophilic Digester	\$ 5,414,000	No	\$ -	No	\$ -	No	\$ -	Yes	\$ 5,414,000	
19	Dewatering Expansion	\$ 8,693,000	Yes	\$ 8,693,000	No	\$ -	No	\$ -	No	\$ -	
20	Dewatering Upgrades	\$ 2,941,000	Yes	\$ 2,941,000	No	\$ -	No	\$ -	No	\$ -	
21	Biogas Flare	\$ 251,000	Yes	\$ 251,000	No	\$ -	No	\$ -	No	\$ -	
22	Sidestream Phosphorus / Struvite Mitigation System	\$ 4,153,000	Yes	\$ 4,153,000	No	\$ -	No	\$ -	No	\$ -	
23	Renewable Natural Gas	\$ 7,667,000	No	\$ -	No	\$ -	Yes	\$ 7,667,000	No	\$ -	
24	Return Pressate Equalization	\$ 455,000	No	\$ -	Yes	\$ 455,000	No	\$ -	No	\$ -	
Solid Stream Total:			\$ 23,795,000		\$ 16,921,000		\$ 7,667,000		\$ 5,414,000		
Civil Site/Support & Electrical Systems		Estimated Cost									
23	Grading, Paving, and Site Drainage	\$ 1,950,000	No	\$ -	No	\$ -	Yes	\$ 1,950,000	No	\$ -	
24	Landscaping and Site Aesthetics	\$ 325,000	No	\$ -	No	\$ -	Yes	\$ 325,000	No	\$ -	
25	Impure Water Building	\$ 1,300,000	No	\$ -	No	\$ -	Yes	\$ 1,300,000	No	\$ -	

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26	Maintenance Building	\$	1,950,000	Yes	\$	1,950,000	No	\$	-	No	\$	-	
27	Electrical Systems - Site Power	\$	10,400,000	Yes	\$	5,200,000	Yes	\$	5,200,000	No	\$	-	
28	SCADA Programming	\$	1,084,200	Yes	\$	1,084,200	No	\$	-	Yes	\$	1,084,200	
30	Site Demo	\$	390,000	No	\$	-	Yes	\$	390,000	No	\$	-	
Civil/Support & Electrical Systems Total:				\$ 8,234,200		\$ 5,590,000		\$ 4,659,200		\$ -			
Temporary or Phasing Related Facilities		Estimated Cost											
31	\$ -	\$	-	No	\$	-	No	\$	-	No	\$	-	
32	Various areas	\$	1,950,000	No	\$	-	No	\$	-	Yes	\$	1,950,000	
33	\$ -	\$	-	No	\$	-	No	\$	-	No	\$	-	
34	\$ -	\$	-	Yes	\$	-	No	\$	-	No	\$	-	
Temporary or Phasing Related Facilities Total:				\$ -		\$ -		\$ 1,950,000		\$ -			
Orem Funded Phase 1 Grand Total:				\$ 57,848,700		\$ 39,717,500		\$ 25,002,200		\$ 37,485,000			
Project to be Funded By Others		Estimated Cost											
35	0	\$	-	No	\$	-	No	\$	-		No	\$	-
Project to be Funded By Others Total:				\$ -		\$ -		\$ -		\$ -			
Project to be Funded By Others Grand Total:				\$ -		\$ -		\$ -		\$ -			
Combined Phase 1 Grand Total:				\$ 58,000,000		\$ 40,000,000		\$ 25,000,000		\$ 37,000,000			

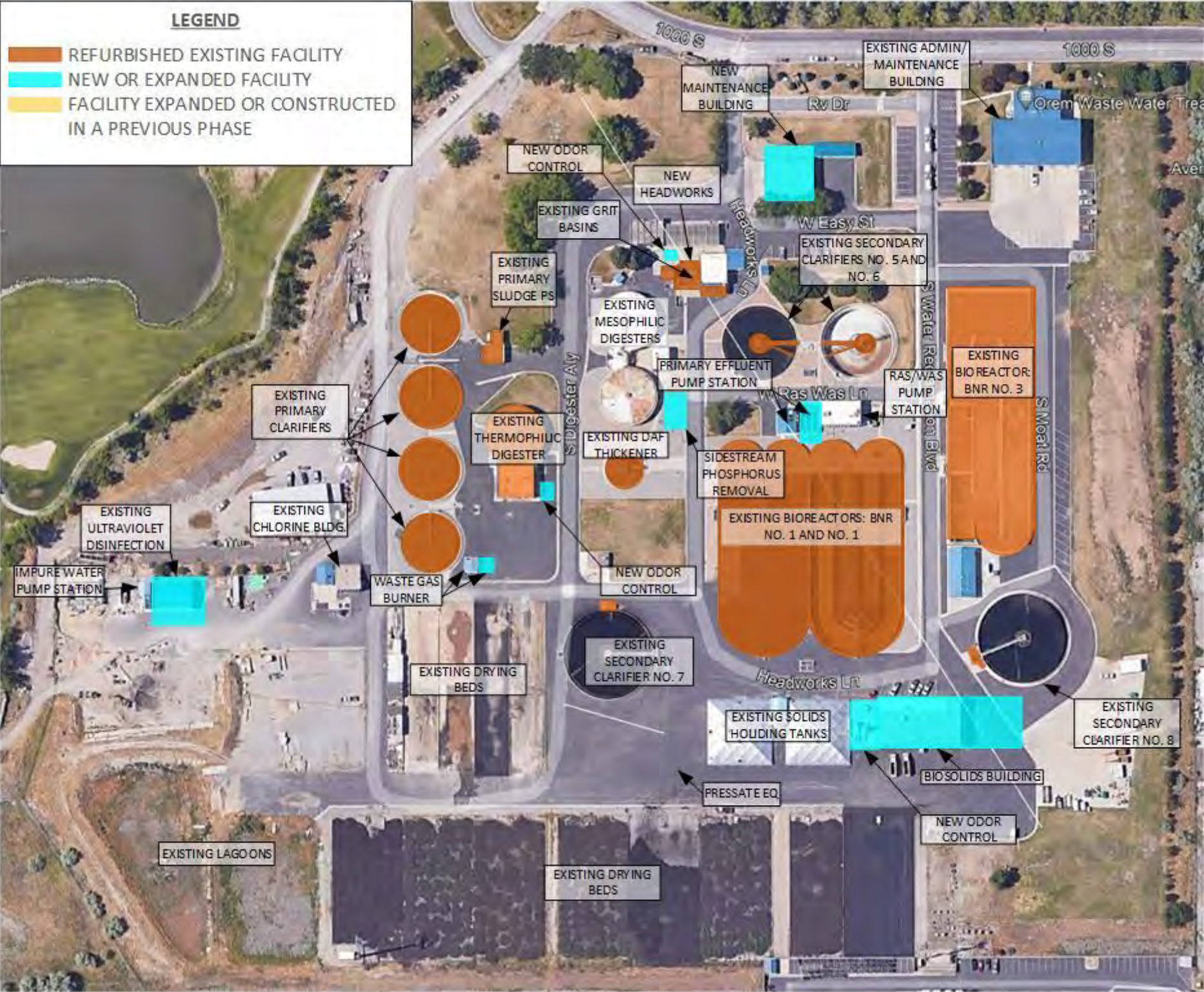


Figure 6-1 – Phase 1 Future OWRF Upgrades

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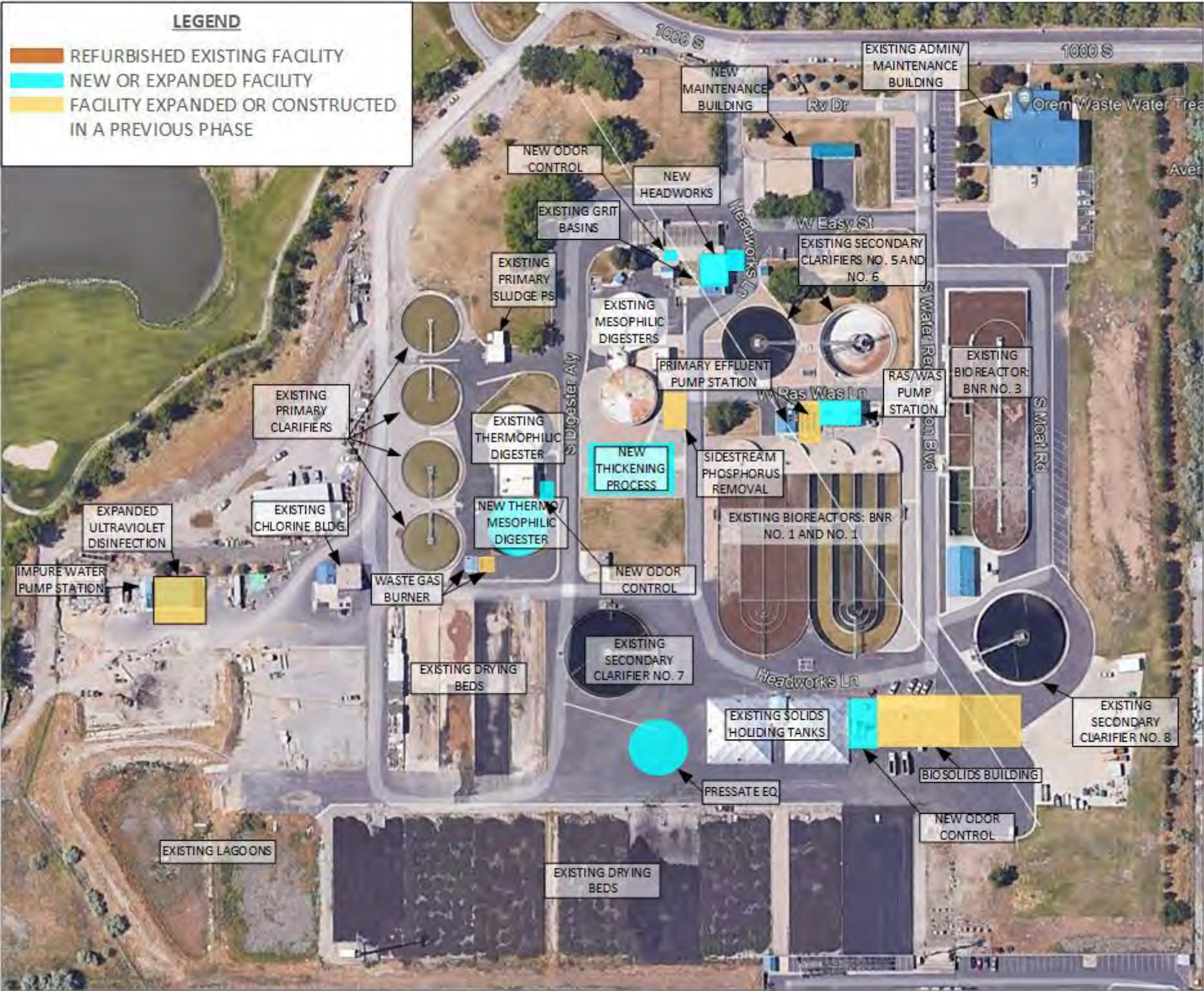


Figure 6-2 – Phase 2 Future OWRF Upgrades

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Figure 6-3 – Phase 3 Future OWRF Upgrades

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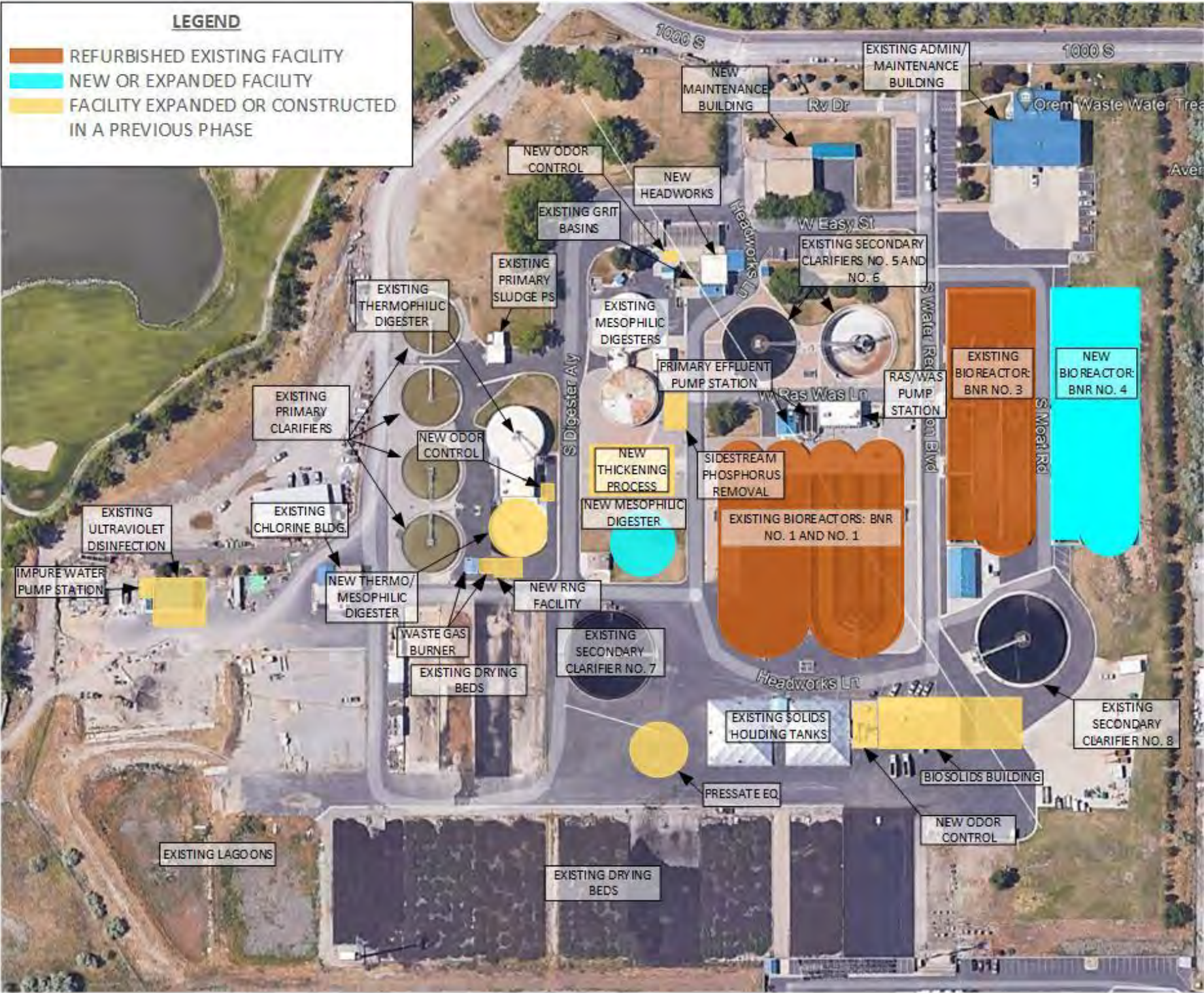


Figure 6-4 – Phase 4 Future OWRF Upgrades

APPENDIX A. **Flows and Loads Technical Memorandum**



**OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
FLOWS AND LOADS MEMORANDUM**

**OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
FLOWS AND LOADS MEMORANDUM**

Date: December 14, 2022
Prepared By: Jayesh Charthal
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Table of Contents

Executive Summary.....	2
Introduction	4
Background	4
1. Requirements from Utah Regulations	4
Flow Projections from Previous Reports	4
1. Orem City Sewer Master Plan (2016)	4
Recent Data.....	5
1. Influent Flow	5
2. Influent Temperature	10
3. Organic and Nutrient Loading.....	11
1.1.1. Annual Average Loading	12
1.1.2. Average Day Maximum Month Loading	16
1.1.3. Design Loading	19
4. Ammonia and Phosphorous Removal	20



Executive Summary

The following key observations were made from the influent wastewater characterization for the period January 2017 to December 2020.

- For the time period analyzed, the Annual Average Day (AAD) Influent flows to the Orem Water Reclamation Facility (OWRF) have remained relatively stable at or near 9 mgd. The design AAD hydraulic capacity of the facility is 13.5 mgd, indicating that the facility is currently operating at approximately 67% of design capacity based on average daily flows.
- The OWRF is currently experiencing peak flows of nearly 21 mgd. The design Peak Hour Flow (PHF) listed in the most recent design documents is 21.6 mgd, indicating that the facility is currently operating at nearly 100% of its design capacity for peak flows. Further analysis of flow data indicates that an appropriate design PHF for the facility based on the 13.5 AAD design flow is 31.7 mgd.
- The evaluation of the raw influent data indicates that the plant experiences significant periods of time with insufficient carbon to completely remove the influent ammonia (NH_3) and phosphorus using biological processes. This carbon limitation may be addressed using various process modifications as discussed in the following paragraphs.
 - The raw wastewater influent biochemical oxygen demand (BOD) to total phosphorus (TP) ratio, (BOD:TP) was less than 20 for approximately 32% of the recorded data. Additionally, the BOD:TP ratio is greater than 30 in only 12% of the recorded data. This indicates that there is insufficient biodegradable carbon for reliable biological phosphorous removal. The OWRF may utilize chemical phosphorus removal processes to meet the Technology Based Phosphorous Effluent Limits (TBPEL) or implement process modifications to increase the amount of biodegradable carbon available for use in biological phosphorus removal processes. Potential process modifications to improve biological phosphorus removal performance include:
 - Primary sludge fermentation to generate readily biodegradable carbon,
 - Intermittent mixing of anaerobic zones to promote fermentation of settled solids to generate readily biodegradable carbon,
 - Return activated sludge (RAS) or mixed liquor fermentation to promote the growth of denitrifying phosphorous accumulating organisms (dPAOs) that remove phosphorous more efficiently,
 - Implement struvite/phosphorus removal from the digested sludge to reduce the amount of phosphorus returned to the liquid stream processes during biosolids stabilization and dewatering.
 - The raw wastewater influent BOD to Total Kjeldahl Nitrogen (TKN) ratio (BOD:TKN) is less than 5 in approximately 52% of the recorded data, indicating that the OWRF may have challenges performing denitrification during such conditions. This indicates that the OWRF may need process modifications to achieve reliable denitrification. Possible process improvements include:
 - Primary sludge fermentation to generate readily biodegradable carbon,

- Intermittent mixing of anaerobic zones to promote fermentation of settled solids to generate readily biodegradable carbon,
- Chemical carbon addition, such as methanol addition within the anoxic zones, to increase the readily biodegradable carbon within the treatment process.

The comparison of the OWRF design loadings, with loadings at AAD and average day maximum month (ADMM) flow conditions during the evaluation period are summarized below:

Table ES-1 OWRF Load Summary

Parameter	AAD Condition	ADMM Condition	OWRF Design ¹
BOD load (lbs/day)	16,232	18,859	39,407 ²
TSS load (lbs/day)	16,910	19,958	39,407 ²
Ammonia load (lbs/day)	2,599	2,938	4,504 ³
TP load (lbs/day)	728	837	N/A
BOD concentration (mg/L)	218	261	350
TSS concentration (mg/L)	227	276	350
Ammonia concentration (mg/L)	34.9	40.6	40.0
TP concentration (mg/L)	9.8	11.6	N/A
TKN _{calculated} concentration (mg/L)	43.6	50.8	50.0
Per capita BOD ₅ contribution ⁴ (lbs/capita/day)	0.15 ⁴	0.17 ⁴	0.30 ⁵
Per capita TSS contribution ⁴ (lbs/capita/day)	0.15 ⁴	0.18 ⁴	0.30 ⁵
Per capita NH ₃ contribution ⁴ (lbs/capita/day)	0.023 ⁴	0.026 ⁴	0.035 ⁵
Per capita TP contribution ⁴ (lbs/capita/day)	0.007 ⁴	0.008 ⁴	N/A
Per capita TKN _{calculated} contribution ⁴ (lbs/capita/day)	0.029 ⁴	0.033 ⁴	0.043 ⁵
1- From available design drawings for design year 2060, Buildout condition 2- Based on design flow of 13.5 mgd and design concentration of 350 mg/L 3- Based on design flow of 13.5 mgd and design concentration of 40 mg/L 4- Service population of 111,000, per City of Orem 2021 Sewer Master Plan. 5- Using design population of 129,900 in year 2060			

An examination of Table ES-1 indicates that the OWRF is currently receiving approximately 50% of the design load for BOD and TSS, and approximately 65% of the design load for ammonia. This indicates that the facility currently has the biological capacity to treat nearly double the loadings currently being experienced. This is a factor of the current flows being lower than the design flow, and the constituent concentrations being less than the design values.

It is noteworthy that the influent BOD concentration at ADMM (261 mg/L) is significantly lower than the design value (350 mg/L), and the influent ammonia concentration at ADMM (40.6 mg/L) is nearly equal to the design value (40.0 mg/L). Recognizing that BOD represents the carbon available for biological processes, this supports the findings discussed above concerning the lack of readily biodegradable carbon in the raw influent necessary to achieve both denitrification and biological phosphorus removal.

Introduction

This memorandum presents the evaluation of the Orem Water Reclamation Facility (OWRF) influent wastewater characterization data for the four-year period of January 2017 to December 2020. The influent flows and loads evaluation will be used to develop the wastewater influent flow, strength, and loading criteria for the capital facilities improvement plan.

Background

1. Requirements from Utah Regulations

Utah Regulation 317-3-4.3, Design Requirements for Wastewater Collection, Treatment and Disposal Systems, requires that a wastewater treatment plant design be based on the higher value of either the moving 30-day average, monthly average, or values “equal to or greater than 92%” of the flow, biochemical oxygen demand (BOD), and total suspended solids (TSS) data. This requires that the plant design (or capacity analysis) be based on the maximum-month wastewater characteristics. The regulations also require that at least one-year’s data be taken as the basis of design, and the analysis consider the effect of shock loadings on the treatment process, including high concentrations and diurnal peaks for short periods of time.

Flow Projections from Previous Reports

1. Orem City Sewer Master Plan (2016)

Bowen Collins & Associates (BC&A) prepared a sewer master plan in 2016 for Orem City’s wastewater collection system. The master plan includes details about Orem City’s future growth and wastewater flow projections. Based on the residential and non-residential population data, water meter data, and total influent data at the OWRF, the domestic wastewater flow contributions were projected. The total domestic wastewater flows were corrected for infiltration to calculate the projected influent to the OWRF. Based on the available data, the master plan concluded that the City’s system does not have potential for significant inflow.

Table 1 summarizes the total domestic flow and the total projected flow into the OWRF. The sewer master plan states the opinion that based on the design hydraulic capacity of the facility, the OWRF has sufficient hydraulic capacity until 2040.

Table 1 - Orem City Sewer Master Plan (2016) Flow Projections

Year	Total Domestic Wastewater Flow ¹ (mgd)	OWRF Projected flow ² (mgd)
2013	8.85	9.79
2020	9.99	11.09
2030	10.90	12.32
2040	11.76	13.27
2050	12.41	13.98

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2060	12.99	14.62
1- Does not include inflow and infiltration (I/I)		
2- Includes infiltration and city does not have potential for significant inflow		

Recent Data

Plant flow and raw wastewater quality data for the 4 year period of January 2017 through December 2020 were analyzed. Data summaries are presented in this section.

1. Influent Flow

Influent wastewater flow is measured at a manhole, prior to the Headworks Building. This flow measurement does not include internal plant recycle flow or internal plant water flow inputs from operational activities such as basin washing, or equipment wash down.

There are gaps in the influent data set for the periods April 2017 (30 days), August 2017 (10 days), September 2017 (10 days), January 2018 (31 days), and August 2018 (31 days). Influent data for these time periods were inferred from a correlation of effluent to influent data. The average ratio of plant effluent to influent in April 2018, 2019, and 2020 was 0.97. this factor was used to estimate influent flows based on the effluent flows for periods where influent flow is not available.

The data set includes some minor inconsistencies such as measured effluent rates that exceed the measured influent rates. These inconsistencies have been included in the analysis of the data set since these values are recorded in the MORs and were submitted to the State of Utah.

The average annual day (AAD) flow for the data set analyzed varies from 8.8 to 9.1 mgd, as shown in Figure 1. The AAD flow over the 4-year analysis period is 8.93 mgd.

The 2020 AAD flow was 20.7% less than the flow predicted in the 2016 sewer master plan. The AAD flow rates between 2017 to 2019 were similar to predicted rates and declined in 2020. A possible reason is the effect of Orem City’s water conservation efforts during the severe drought. Figure 2 shows the annual precipitation for 2017 through 2020. The annual precipitation in 2020 dropped by approximately 67% compared to 2018 and 2019, and by 33% compared to 2017. The daily influent flow to the OWRF was plotted against the total precipitation for the four-year period of January 2017 to November 2020. See Figure 3. The figure does not show a significant correlation between the influent flow rate and total precipitation, indicating that inflow and infiltration does not significantly impact the facility’s influent flow rate.

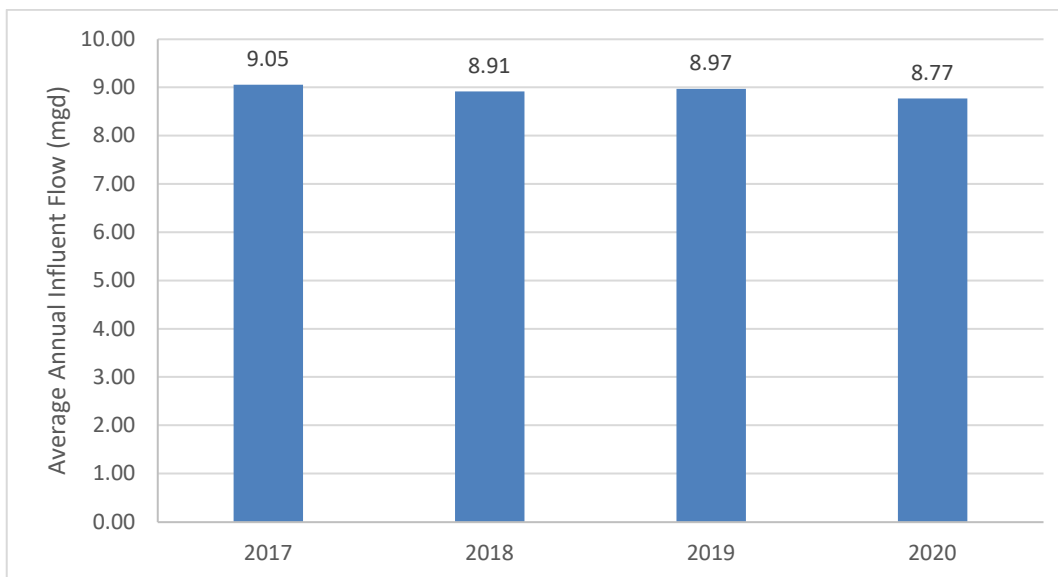
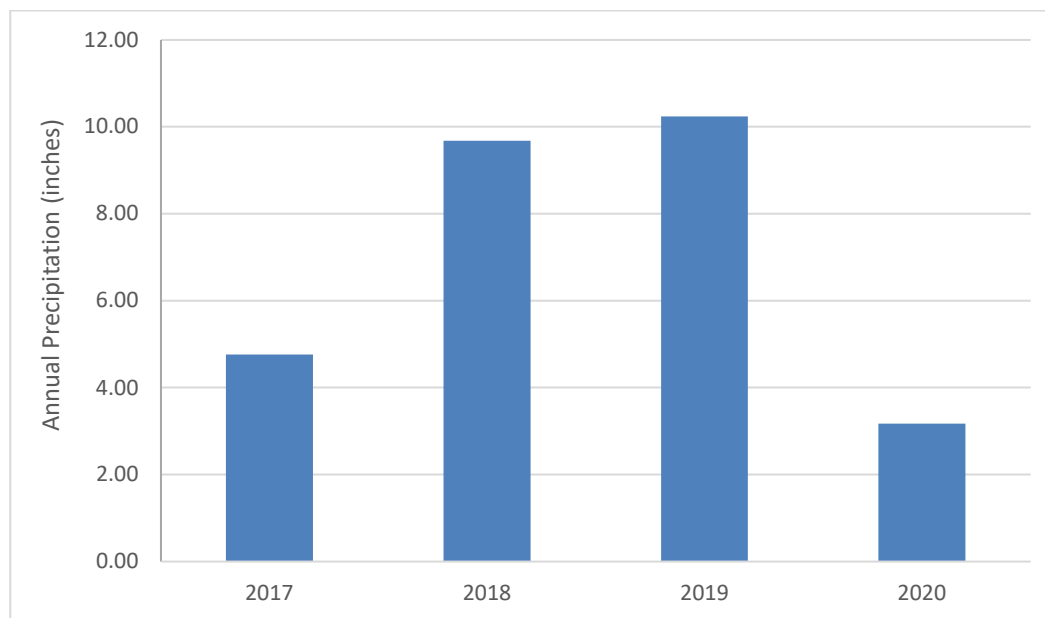
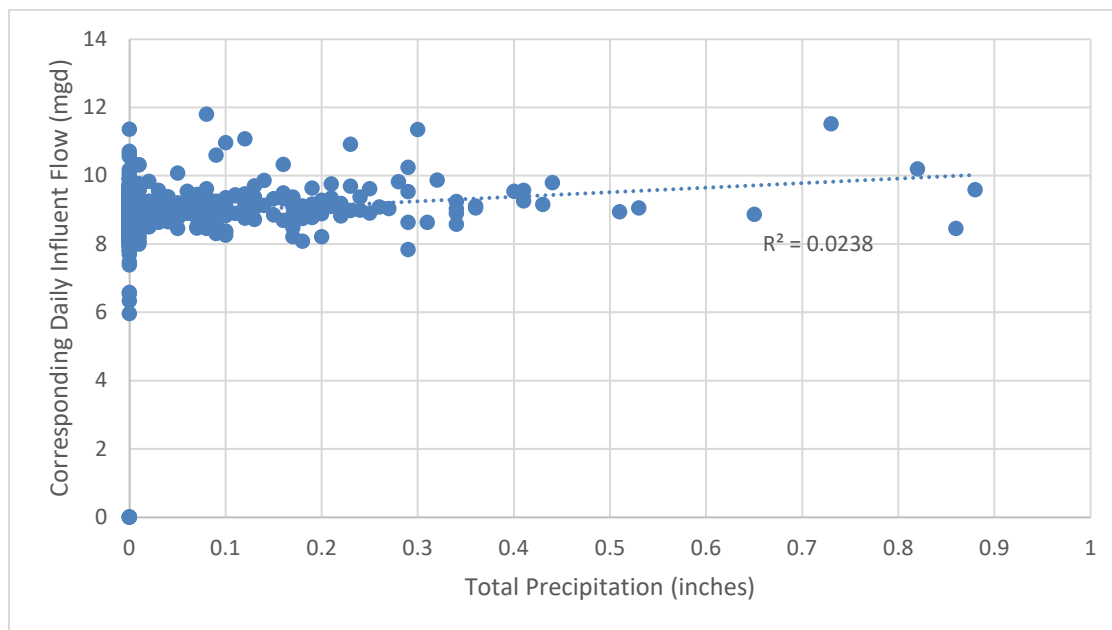


Figure 1 - Average Daily Wastewater Flow



*Total precipitation reported is a sum of rainfall and snow fall.

Figure 2 - Annual Precipitation



*Total precipitation reported is a sum of rainfall and snow fall.

Figure 3 - Correlation between the influent flow and precipitation

The monthly wastewater flow does not vary significantly, as indicated by Figure 4. The influent flow rates appear to be lowest in the months of April, November and December, and highest in January and February.

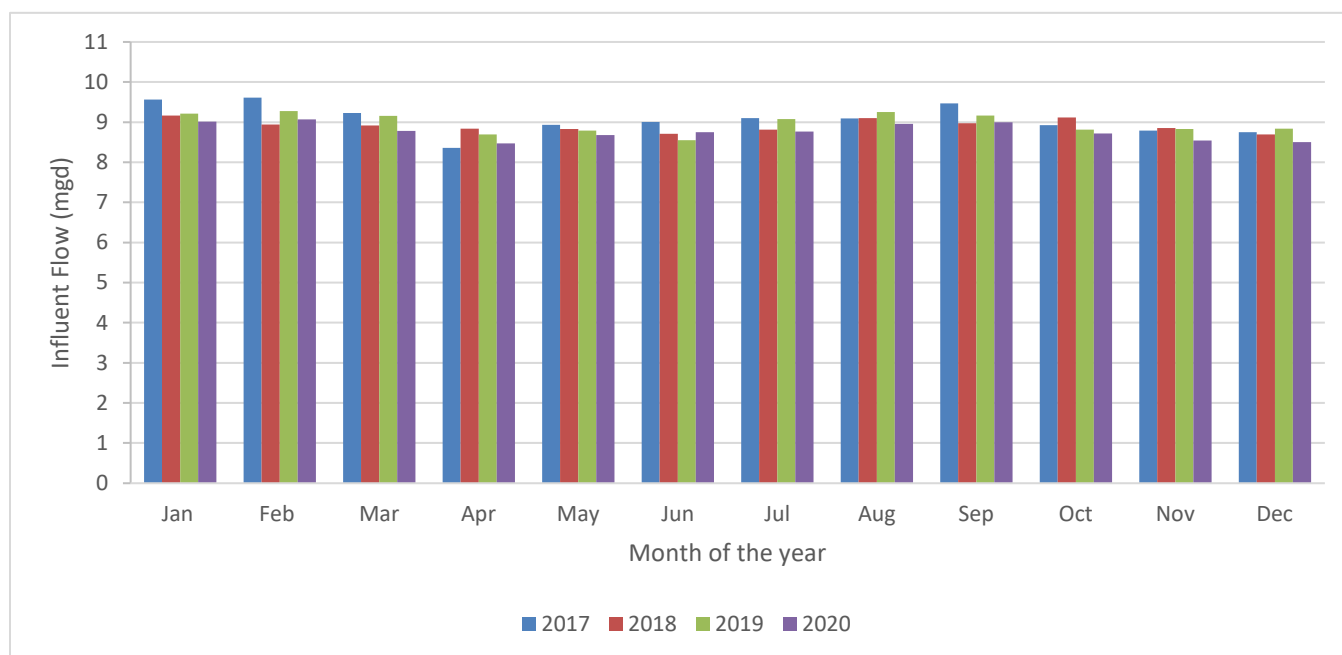


Figure 4 - Average Monthly Influent Flow

As shown in Figure 5, it was observed that the influent flow to the OWRF declines slightly on Fridays and Sundays compared to other days of the week and increases on Saturdays and Mondays. An explanation for this pattern was not determined.

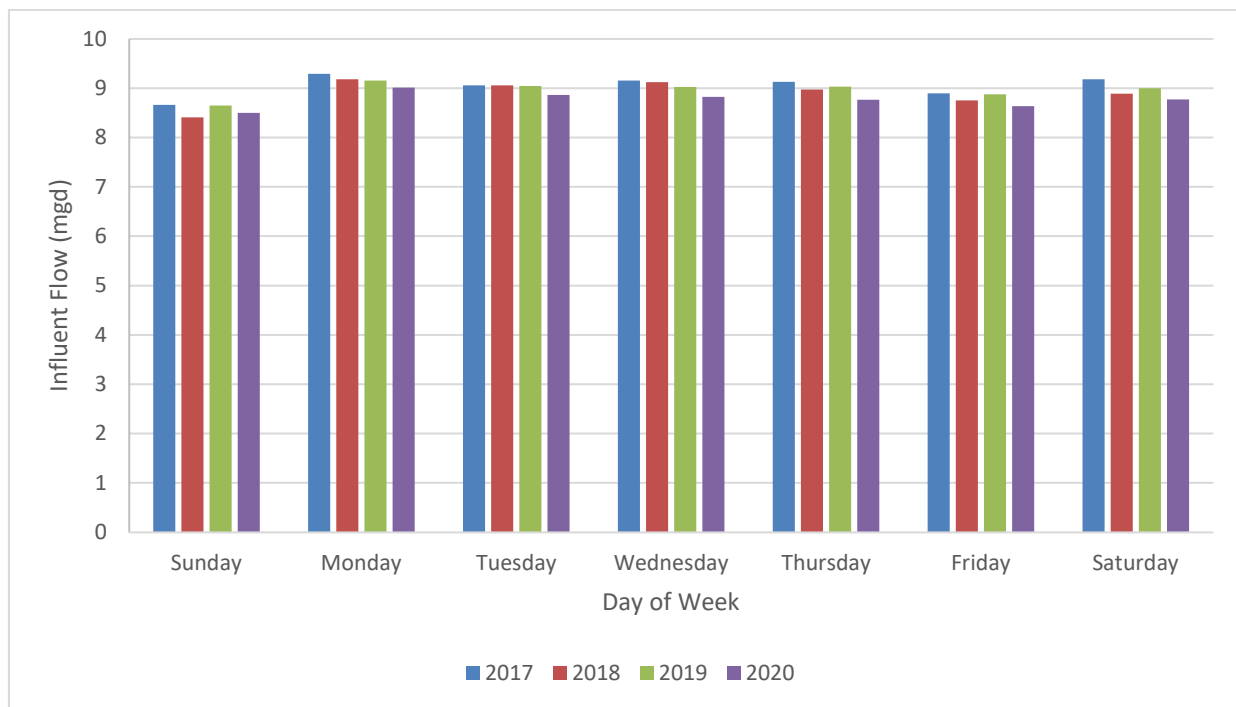


Figure 5 - Average Day Influent Flow by Day of Week

The regulations and definitions related to design flow rates and wastewater strength established by Utah Regulation 317-3, Design Requirements for Wastewater Collection, Treatment and Disposal Systems, are summarized in Table 2. These regulations and definitions were used to calculate the design flows summarized in Table 3.

Table 2 - Utah Regulation 317-3 Pertinent Definitions and Regulations

Parameter	Regulation and/or Definition
Annual Average Day Flow Rate (AAD)	Average of daily rates of flow over a period not <1 year; or Flow rate > 50% of the daily flow rate data
Average Design Flow Rate (average peak-monthly flow rate) (average day maximum month flow rate -ADMM)	Highest value of the: 30-day moving average; or Monthly average; or Value > 92% of daily flow rate
Maximum Design Flow Rate or Peak Day Flow Rate (PDF)	Maximum rate over a 24-hour period; or Flow rate > 99.7% of daily flow data

Peak Design Flow Rate or Peak Hour Flow Rate (PHF)	Maximum rate over a 60-minute period; or Rate > 99.9% of daily flow data
Minimum Day Flow Rate	Minimum rate over a 24-hour period
Hydraulic Design	All units and conveyance structures must have sufficient hydraulic capacity, with one largest unit out of service, to handle maximum and average design rates of flow without overtopping

State regulations require that the OWRF have the hydraulic capacity to meet AAD and peak hour flow (PHF) conditions. An evaluation of the influent flow data indicates that PHF as defined in Table 2 is 2.35 times AAD flow. Design flows calculated in accordance with the Utah State requirements are summarized in Table 3. The comparison of current flows and the facility design flows indicates that the facility is currently operating at 66% of design flow for AAD but is experiencing 100% of design flow at peak hour conditions. This typically indicates that a facility is experiencing very high inflow and infiltration (I&I), but as discussed above, flow and precipitation data indicate that the Orem collection system is experiencing low I&I. It appears that the design PHF utilized an AAD:PHF flow factor of 1.6, which is insufficient based on the current data analyzed in this evaluation. Further evaluation of the OWRF hydraulic capacity will be conducted to determine the facility's maximum hydraulic capacity and identify the processes and equipment that are the limiting hydraulic elements within the facility.

Table 3 - Summary of Influent Flow per Utah Regulation 317-3

Parameter	Flow Factor ¹	Flow (mgd)	OWRF Design Flow ² (mgd)
AAD	1.00	8.93	13.5
ADMM	1.08	9.62	N/A
PDF	1.52	13.56	N/A
PHF ³	2.35	21.03	19.6 ⁴ /21.6 ⁵
Minimum Day Flow	0.54	4.82	N/A
1- Flow factor is the ratio of the subject flow to AAD flow 2- From available design drawings for design year 2060, Buildout condition 3- PHF is based on hourly flow rate available from Jan 2014 to August 2018 4- Intermediate Peak Hour Flow as per 2013 UV Disinfection 5- Peak Hour Flow for design year 2060, Buildout condition			

Figure 6 presents representative diurnal flow patterns observed on various days in 2017 and 2018.

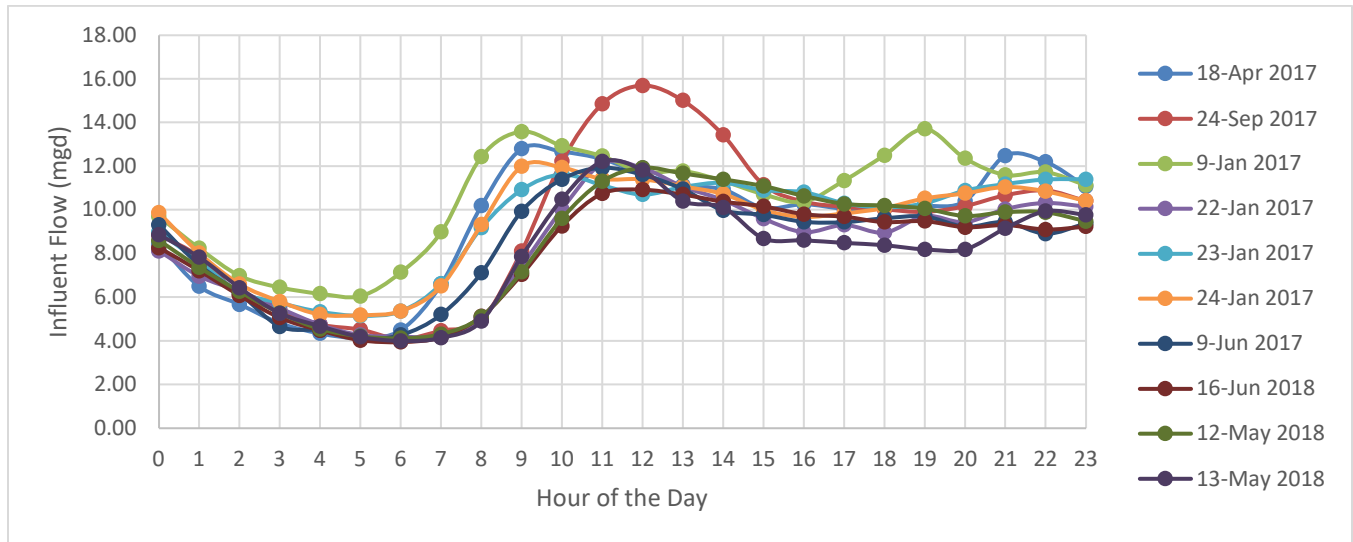


Figure 6 - Diurnal Flow Pattern

The following observations were made from Figure 6:

- OWRF receives the least amount of flow, as low as 4 mgd, between 3:00 AM and 8:00 AM. Between 9:00 AM and 2:00 PM influent flow increases above AAD up to 14 mgd. After 3:00 PM, the OWRF usually receives AAD flow and stays nearly constant.
- Some variations in the diurnal flow pattern peaks are observed. These variations did not correlate with precipitation events.

2. Influent Temperature

Figure 7 presents the average monthly temperature of influent wastewater at the OWRF.

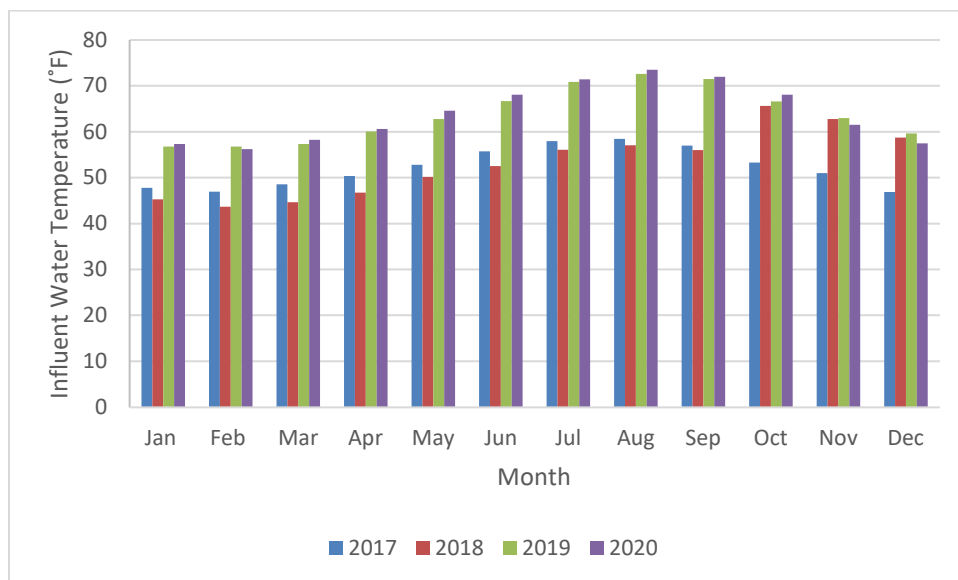


Figure 7 Average Monthly Influent Wastewater Temperature

An examination of Figure 7 indicates that the annual average influent wastewater temperature for 2017 and 2018 was 52°F to 53°F, and 64°F in 2019 and 2020. The 10°F temperature shift occurred in October 2018. The OWRF staff clarified that the temperature instrument had calibration issues and temperature data after October 2018 should be considered for analysis purpose.

Minimum month temperature is typically observed in February and maximum month temperature is typically observed in August. For period between October 2018 to December 2020, a minimum winter temperature of 56°F was observed in February 2020 and maximum summer temperature of 73°F was observed in August 2020. Thus, winter temperature of 56°F and summer temperature of 73°F shall be used for future plant capacity and modeling analyses.

3. Organic and Nutrient Loading

The organic strength of the raw wastewater is determined from the BOD and TSS analysis on influent composite water samples. TSS and BOD composite sample data from the January 2017 through December 2020 period were analyzed.

Total Kjeldahl Nitrogen (TKN) and Total Phosphorous (TP) are measures of raw wastewater nutrient characteristics. Raw wastewater TKN and TP analysis is conducted on composite raw wastewater samples once every month. This generates a very small data set for use in the loading analysis. More frequent sampling over a minimum time period of one year is typically used to gather sufficient TKN and TP measurements to adequately capture seasonal variations.

The collection of grab samples for TP analysis is significantly more frequent than the collection of composite samples (grab samples were collected on 43% of the days in 2018, and approximately 63% of the days in 2019 to 2020). Due to the limited data available from composite sampling, the TP grab sample data has been utilized to conduct the OWRF phosphorus load analysis.

The available TP data collected from grab samples is compared to the data collected from composite samples in Figure 8. This comparison indicates that measured TP in the grab samples is always higher than the measured TP in the composite samples. This is an expected result since grab samples are typically collected during the normal workday, when nutrient loadings are at their highest, and composite samples collect a more representative sample from an entire 24 hour period. Use of the grab sample data for the loading analysis will result in the overestimation of phosphorus load, which will be considered in the process evaluation.

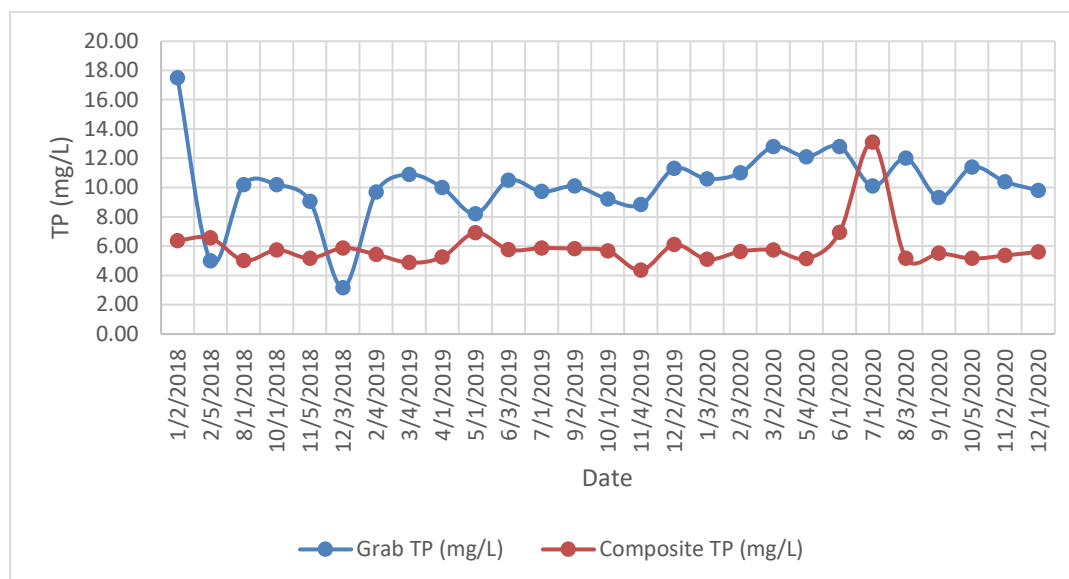


Figure 8 Raw wastewater Grab vs Composite TP Test Result (2018 to 2020)

TKN was measured once a month in the composite influent samples collected and was not measured in the grab samples. The ratio of TKN measurement from the composite samples to the ammonia measurement from the grab samples ranges from 0.6 to 0.95 and averages 0.72. However, the data set is very small and the assessment is conducted on dissimilar samples, making it challenging to determine a reliable ratio for use in the process evaluation. For a typical composition of untreated domestic wastewater, the Design of Municipal Wastewater Treatment Plants WEF Manual of Practice No. 8 (MOP 8) suggests that the typical NH_3 :TKN ratio is 0.55 to 0.65. At the Provo City Water Reclamation Facility (PCWRF), extensive sampling and analysis were utilized, resulting in an NH_3 :TKN ratio of 0.93. Considering the similarity in location and constituents of the Orem City and Provo City service areas, a similar, higher, NH_3 :TKN ratio can be reasonably expected. A TKN: NH_3 ratio of 0.8 has been used to estimate the TKN concentration for samples that were analyzed for ammonia.

1.1.1. Annual Average Loading

The measured concentrations of BOD and TSS from composite samples and the ammonia and TP concentrations from the grab samples were combined with the measured flow rate on the sampling dates to determine the organic and nutrient mass loading. Figure 9 presents the annual average organic and nutrient loadings and Figure 10 presents the annual average organic and nutrient concentrations for the years 2017 to 2020.

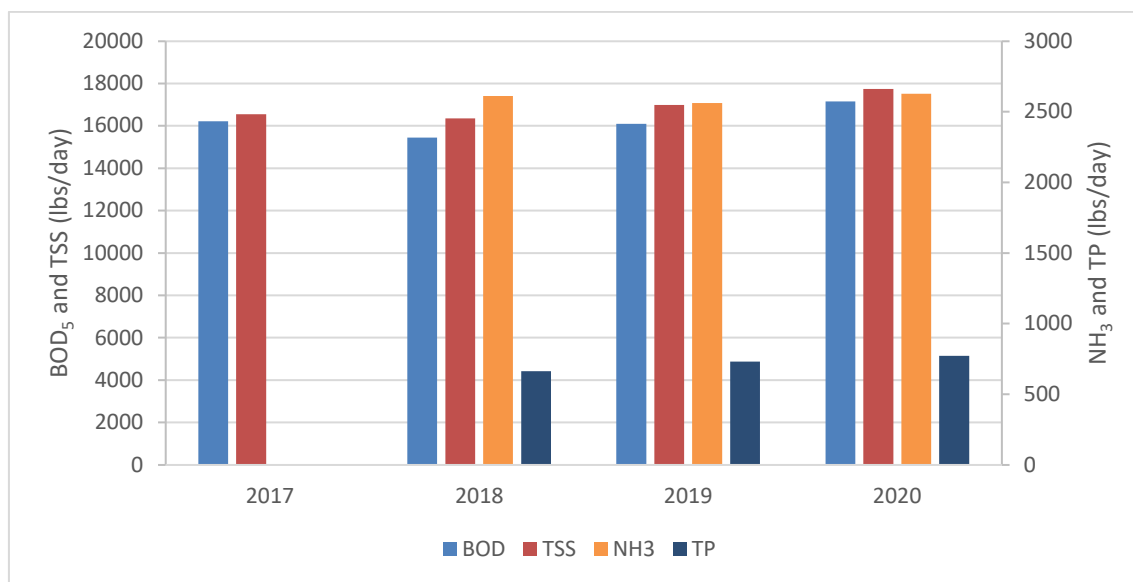


Figure 9 - Annual Average Organic and Nutrient Mass Loading for years 2017 to 2020

Figure 9 indicates that the BOD and TSS mass loadings have increased slightly over the study period. In 2018, BOD concentrations decreased significantly resulting in a lower BOD mass loading. TSS loading in 2018 did not decline to a similar extent, so this decrease in BOD loading is expected to be atypical and not representative of the loading trend for the facility.

The ammonia and TP mass loadings have stayed relatively stable for the study period, with the highest ammonia and TP mass loadings occurring in 2020. Ammonia and TP concentrations were highest in 2020, and their associated influent flow rates were lower than in previous years. This may be in response to lower I&I in the collection system due to the lower precipitation during this period. The resultant increase in loading will be considered in the process analysis and compared with 2021 data as it becomes available to determine if there is a trend toward higher loadings.

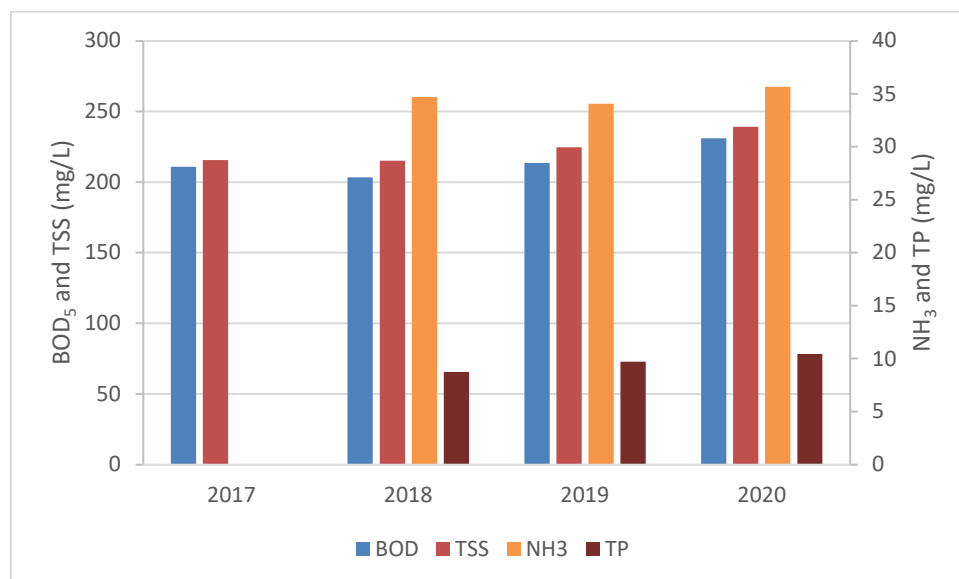


Figure 10 - Organic and Nutrient concentration for years 2017 to 2020

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Figure 11 presents the average monthly BOD loadings. BOD loading is typically highest in the months of January and February when temperatures are low. Lower temperatures result in lower biological treatment performance. This is notable because the highest BOD loadings are occurring during the period where treatment process performance is expected to be at its lowest efficiency.

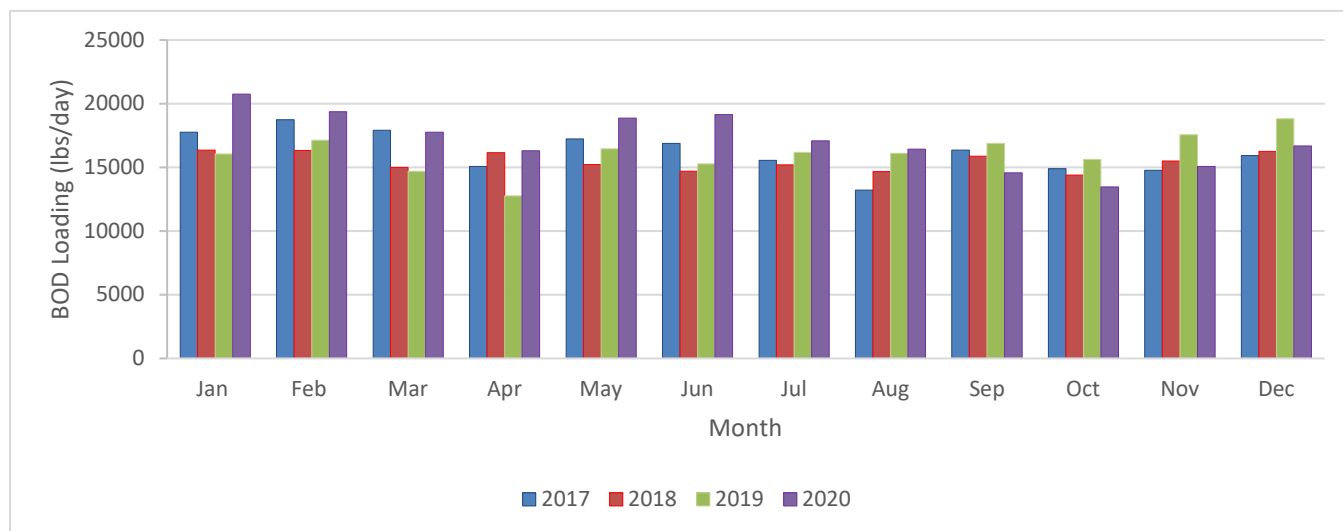


Figure 11 - Average Monthly BOD₅ loading

Figure 12 presents the average monthly TSS loading. TSS loading is relatively stable throughout the year, with the highest observed loadings occurring in winter and early spring. This is consistent with the findings for the BOD loading.

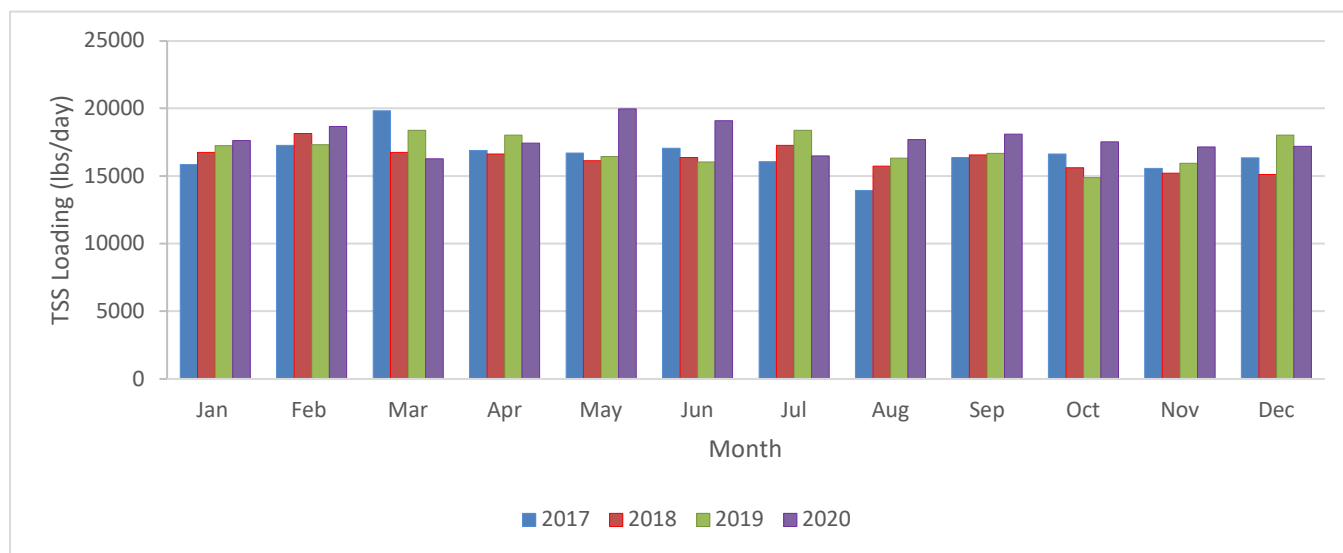


Figure 12 - Average Monthly TSS loading

Figure 13 presents the average monthly ammonia loading. Ammonia loading is typically highest in December, January, and February, although unusually high ammonia loadings were observed in May,

June, and July of 2020. Nitrification typically slows in cold temperatures, so meeting stringent ammonia limits with increased loading during cold weather is challenging. Figure 13 shows that in 2017 and 2018 the average monthly ammonia loading decreased from the beginning of the year into the summer months, and then increases from the summer into fall and winter. In 2020, ammonia loadings tend to follow a similar trend to the 2017 and 2018 data except in May-July where they are unusually high, and September-November where they are unusually low.

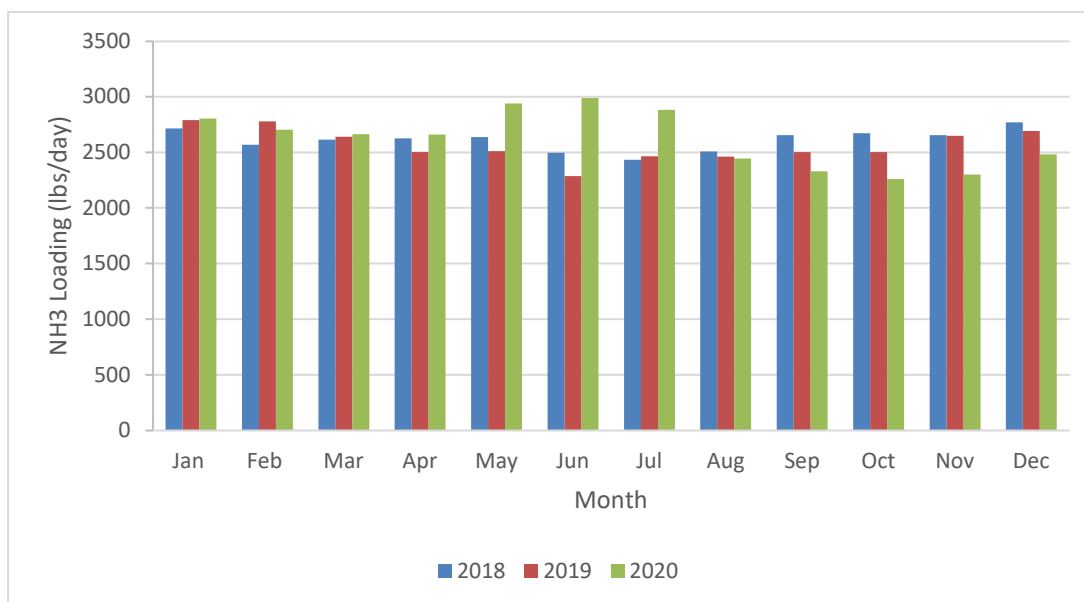


Figure 13- Average Monthly NH₃ loading

Figure 14 presents the average monthly TP loading. In January 2018, a very high TP loading was observed. OWRF staff indicated that there is no explanation for this data point and since this extremely high loading has not been observed in any of the data collected subsequently, that data point will not be considered for loading calculations. There was no particular trend observed for TP loading.

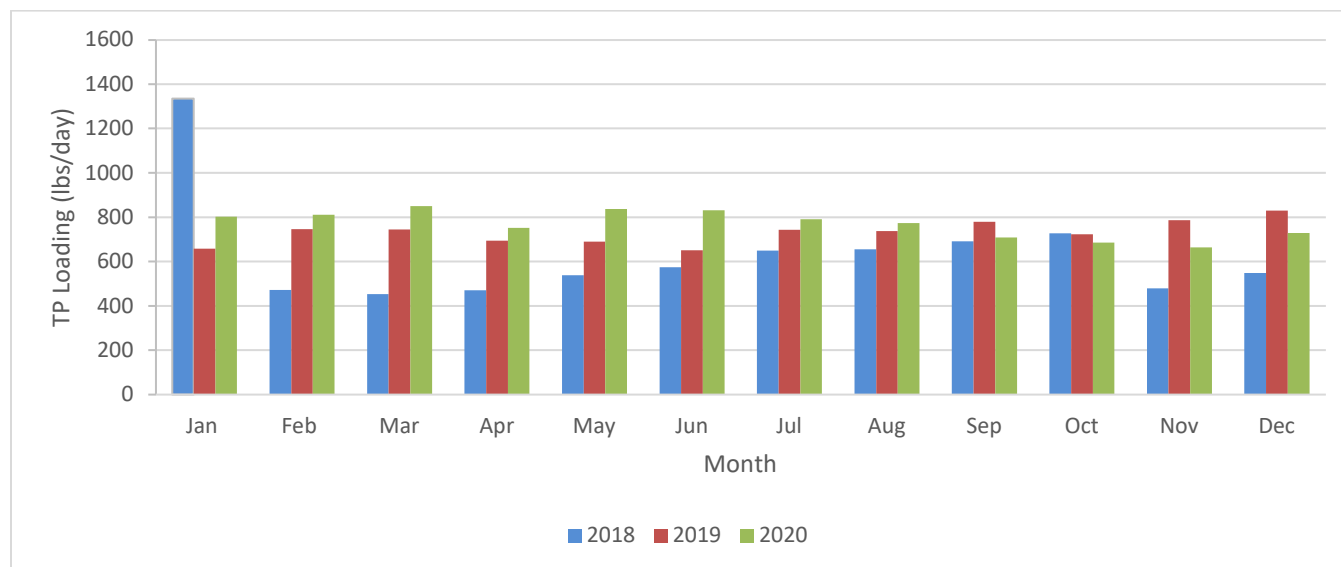


Figure 14 - Average Monthly TP loading

The BOD, TSS, ammonia and TP samples are not collected every weekday, and typically are not collected on Saturdays and Sundays. Due to the lack of consistent daily data, a comparison of daily organic and nutrient loadings was not considered. Although trending daily loadings is sometimes helpful in operational planning, it is not necessary for the evaluation of overall plant performance.

Table 4 summarizes the annual average organic and nutrient loadings and concentrations for January 2017 through December 2020. Reports of 'equivalent population', which consider both residential and nonresidential population are not available. Thus, the residential population was used for calculating a per capita loading contribution for all parameters in this document.

Table 4 - AAD Loading Summary

Parameter	BOD	TSS	Ammonia	TP	TKN _{calculated}
Annual Average Loading (lbs/day)	16,232	16,910	2,599	728	3,249
Flow	8.93	8.93	8.93	8.93	8.93
Annual Average Concentration (mg/L)	218	227	34.9	9.8	43.6
Per capita contribution ¹ (lbs/capita/day)	0.15	0.15	0.023	0.007	0.029
1- Service population of 111,000, per City of Orem 2021 Sewer Master Plan.					

1.1.2. Average Day Maximum Month Loading

Utah Regulation 317-3, Design Requirements for Wastewater Collection, Treatment, and Disposal Systems, establishes regulations and definitions for determining design wastewater strength. These requirements are summarized in Table 5. Since the Utah regulations do not provide requirements for TKN, the Ten State Standards are referenced for TKN loading.

Table 5 - Utah Regulation 317-3 Pertinent Definitions and Regulations

Parameter	Regulation and/or Definition
-----------	------------------------------

Design	<i>The plant design shall be based on the higher values of:</i> a moving average of daily rates of flow and wastewater strength as measured by five-day biochemical oxygen demand (BOD₅) and suspended solids determination tests over a period of 30 consecutive days; or an average of rate of flow and wastewater strength values as measured by five-day biochemical oxygen demand (BOD₅) and suspended solids determination tests, over a period of a month; or the rate of flow and wastewater strength as measured by five-day biochemical oxygen demand (BOD₅) and suspended solids determination tests, equal to or greater than 92% of the daily flow rate and wastewater strength data
Organic Design BOD ₅ TSS	<i>New Systems</i> > 0.17 pounds (200 mg/L) BOD₅ per capita per day > 0.20 pounds (250 mg/L) TSS per capita per day <i>Unless information is submitted to justify alternate designs</i> <i>New Systems – with Food Grinders</i> > 0.22 pounds (260 mg/L) BOD₅ per capita per day > 0.25 pounds (300 mg/L) TSS per capita per day Design allowance for industrial wastewaters and infiltration/inflow rates <i>Existing Systems</i> Use historical BOD₅ and TSS data over a minimum one-year period and “an appropriate increment of growth”
Nutrients TKN	<i>Ten State Standards</i> > 0.046 pounds TKN per capita per day
Shock Loadings	Consider shock loadings of high concentrations and diurnal peaks

The measured concentrations of BOD and TSS from composite samples, and ammonia and TP concentrations from grab samples were used with the daily flow rate measured on the sampling day to determine daily organic and nutrient mass loadings.

As the BOD, TSS, ammonia, and TP concentrations were not measured every day, loading calculations using a 30-day moving average was not used. Instead, calculation of organic and nutrient loadings were completed by determining the 92nd percentile for the loadings as outlined in R317-3.

Table 6 summarizes the calculated ADMM loadings.

Table 6 - ADMM Loading using 92 percentiles of the Data

Parameter	Loading (lbs/day)	Concentration ¹ (mg/L)	Per Capita Contribution ² (lbs/capita/day)
BOD ₅	20,674	258	0.19

TSS	20,681	258	0.19
NH ₃	2,930	36.5	0.026
TP	905	11.3	0.008
TKN _{calculated}	3,663	45.7	0.033
1- Using calculated ADMM flow of 9.62 mgd from Table 3			
2- Service population of 111,000, per City of Orem 2021 Sewer Master Plan.			

These loadings may be used to assess the performance of the OWRF for each constituent independently. The performance of the OWRF should not be analyzed assuming that all of these loadings occur at the same time, since the probability of the facility experiencing the maximum loading for all constituents on the same day is exceedingly low.

The procedure for evaluating the facility's performance under ADMM conditions is as follows: Daily organic and nutrient mass loading data are used to determine the average monthly loading for the years 2017 to 2020. The month in which the BOD loading is the highest is considered as the ADMM BOD loading month. Corresponding TSS, ammonia, and TP loads from the same month are considered as the ADMM BOD loading conditions. Similar ADMM loading conditions for TSS, ammonia and TP are determined using a similar approach. Table 7 summarizes the ADMM organic and nutrient loadings calculated in this way.

Table 7 - ADMM Loading Summary using Average Monthly Loading

Parameter	ADMM BOD Load Condition	ADMM TSS Load Condition	ADMM Ammonia Load Condition	ADMM TP Load Condition
BOD (lbs/day)	20,742	18,859	19,148	17,765
TSS (lbs/day)	17,617	19,958	19,076	16,261
Ammonia (lbs/day)	2,803	2,938	2,988	2,662
TP (lbs/day)	802	837	830	851
Flow during ADMM loading Condition (mgd)	9.01	8.68	8.75	8.78
BOD (mg/L)	276	261	262	243
TSS (mg/L)	234	276	261	222
Ammonia (mg/L)	37.3	40.6	41.0	36.4
TP (mg/L)	10.7	11.6	11.4	11.6
TKN _{calculated} (mg/L)	46.6	50.8	51.2	45.4
ADMM Condition Year	2020	2020	2020	2020
ADMM Condition Month	January	May	June	March
Average Influent Temperature during ADMM load Condition (°F)	57.4	64.6	68.1	58.2
Per capita BOD contribution ¹ (lbs/capita/day)	0.19	0.17	0.17	0.16

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Per capita TSS contribution ¹ (lbs/capita/day)	0.16	0.18	0.17	0.15
Per capita ammonia contribution ¹ (lbs/capita/day)	0.025	0.026	0.027	0.024
Per capita TP contribution ¹ (lbs/capita/day)	0.007	0.008	0.007	0.008
Per capita TKN _{calculated} contribution ¹ (lbs/capita/day)	0.032	0.033	0.034	0.030
1- Service population of 111,000, per City of Orem 2021 Sewer Master Plan.				

Based on an examination of the ADMM loading information above, the ADMM TSS load condition results in a lower amount of biodegradable chemical oxygen demand available for nutrient removal when compared with the ADMM BOD load condition. Also, ammonia and TP loads for the ADMM TSS load condition are only 2% lower than the ADMM ammonia and ADMM TP load conditions. Due to these factors, using the ADMM TSS load condition will result in the most conservative evaluation of the facility's capacity to remove nutrients, and will be used in the process analysis.

1.1.3. Design Loading

The available 2010 OWRF upgrade design drawings and the 2013 UV disinfection drawings contain current BOD, TSS and ammonia design loads, which are summarized in Table 8. Data on TP design loading is not available.

The AAD loading described in paragraph 1.1.1 and ADMM loading described in paragraph 1.1.2 are summarized in Table 8 and are compared against the OWRF's design capacity.

Table 8 - OWRF Load Summary

Parameter	AAD Condition	ADMM Condition	OWRF Design ¹
BOD ₅ load (lbs/day)	16,232	18,859	39,407 ²
TSS load (lbs/day)	16,910	19,958	39,407 ²
NH ₃ load (lbs/day)	2,599	2,938	4,504 ³
TP load (lbs/day)	728	837	N/A
BOD ₅ concentration (mg/L)	218	261	350
TSS concentration (mg/L)	227	276	350
NH ₃ concentration (mg/L)	34.9	40.6	40.0
TP concentration (mg/L)	9.8	11.6	N/A
TKN _{calculated} concentration (mg/L)	43.6	50.8	50.0
Per capita BOD ₅ contribution ⁴ (lbs/capita/day)	0.15 ⁴	0.17 ⁴	0.30 ⁵
Per capita TSS contribution ⁴ (lbs/capita/day)	0.15 ⁴	0.18 ⁴	0.30 ⁵
Per capita NH ₃ contribution ⁴ (lbs/capita/day)	0.023 ⁴	0.026 ⁴	0.035 ⁵
Per capita TP contribution ⁴ (lbs/capita/day)	0.007 ⁴	0.008 ⁴	N/A
Per capita TKN _{calculated} contribution ⁴ (lbs/capita/day)	0.029 ⁴	0.033 ⁴	0.043 ⁵

- 1- From available design drawings for design year 2060, Buildout condition
- 2- Based on design flow of 13.5 mgd and design concentration of 350 mg/L
- 3- Based on design flow of 13.5 mgd and design concentration of 40 mg/L
- 4- Service population of 111,000, per City of Orem 2021 Sewer Master Plan.
- 5- Using design population of 129,900 in year 2060

An examination of Table 9 indicates that the current loadings at the OWRF are approximately 50% of the design loadings for BOD and TSS, and approximately 65% of the design loading for ammonia. Additionally, per capita ammonia loading is 74% of the design value.

It is also observed that calculated per capita organic and nutrient loading contributions for the study period are low when compared to the suggested design values for a new system presented in Table 5.

4. Ammonia and Phosphorous Removal

A BOD:TKN ratio of 5 is recommended for reliable denitrification when included in the biological phosphorous removal process. Figure 15 shows the BOD:TKN ratio observed between years 2018 and 2020. For approximately 52% of the recorded data points, the BOD:TKN ratio is less than 5, indicating that the OWRF may frequently have denitrification challenges due to carbon limitation. The above analysis is based on the assumption of a NH_3 :TKN ratio of 0.8 as discussed in paragraph 3. If the actual ratio proves less than 0.8 then the denitrification efficiency may be further affected. Therefore, OWRF staff are encouraged to measure NH_3 , TP, TKN, and VSS from composite influent samples at the same frequency as BOD and TSS.

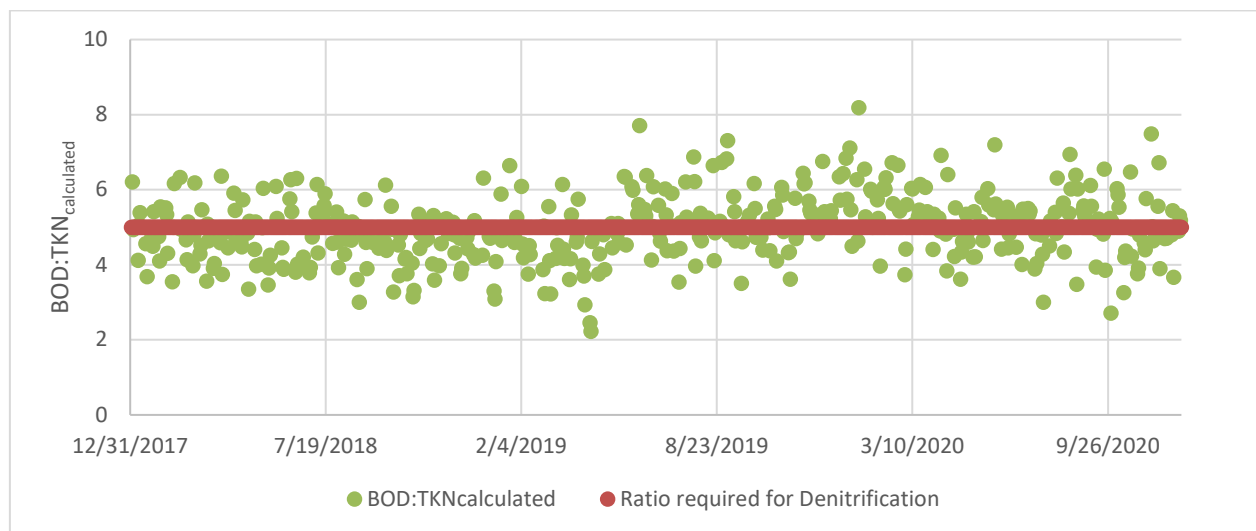


Figure 15 - BOD:TKN ratio between year 2018 and 2020

For effective phosphorous removal, a sufficient population of PAOs needs to be maintained in the bioreactors. Typically, a BOD:TP ratio of 20 is suggested for enhanced biological phosphorus removal (EBPR) and a BOD:TP ratio of 30 is suggested for achieving effluent TP concentrations below 0.5 mg/L. Figure 16 presents BOD:TP ratios observed between 2018 and 2020.

Figure 16 shows that the raw wastewater influent BOD:TP ratio is less than 20 for approximately 32% of the data, suggesting the lack of biodegradable carbon availability for PAO performance. Additionally, only 12% of the data indicate a BOD:TP ratio of more than 30. This suggests that the OWRF may

require process modifications to meet the regulatory limit for effluent total phosphorous using biological phosphorus removal.

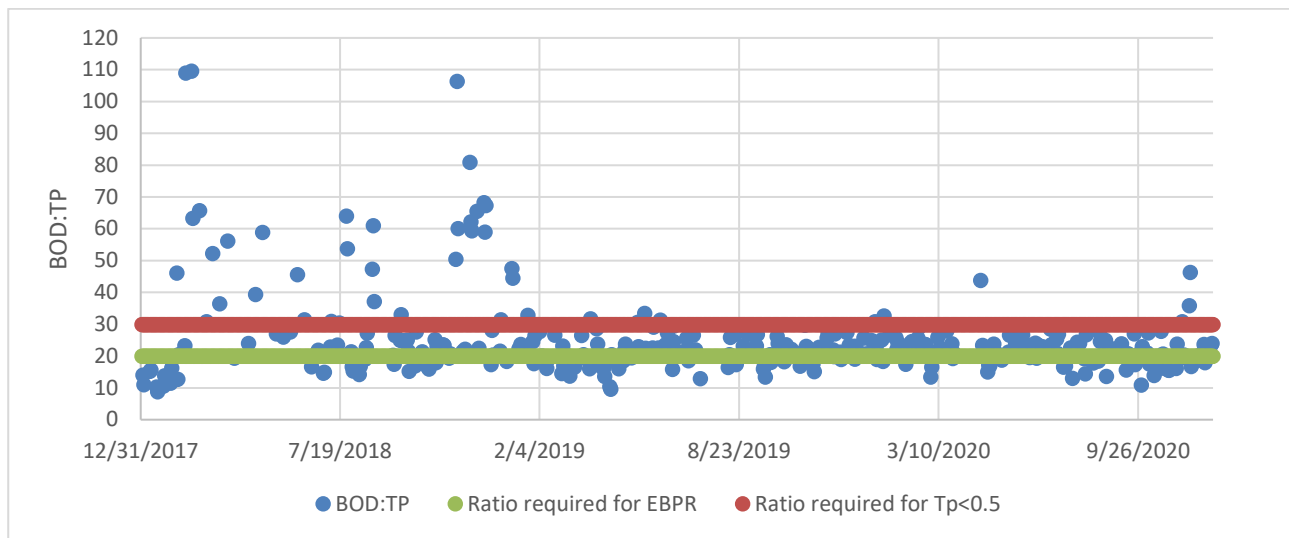


Figure 16 - BOD:TP ratio between year 2018 and 2020

APPENDIX B. **Hydraulic Capacity Technical Memorandum**



OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
HYDRAULIC CAPACITY TECHNICAL MEMORANDUM

OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
HYDRAULIC CAPACITY TECHNICAL MEMORANDUM

Date: December 14, 2022
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Table of Contents

Executive Summary.....	3
1 Hydraulic Capacity Analysis	5
1.1 Hydraulic Model Development	5
1.1.1 Model Assumptions	5
1.1.2 Flow Rate Analysis	5
1.2 Hydraulic Model Calibration	6
2 Failure Criticality	6
2.1 Hydraulic Analysis – Liquid Stream Process Units.....	7
2.1.1 Ultraviolet Disinfection	7
2.1.2 Parshall Flume (Effluent Flow Measurement)	9
2.1.3 Bioreactors.....	9
2.1.4 Primary Effluent Pump Stations.....	10
2.1.5 Primary Clarifiers.....	11
2.1.6 Headworks Effluent Flume.....	12
2.1.7 Plant Influent Pipe.....	12
2.2 Hydraulic Bottlenecks.....	12
2.2.1 Current Capacity	13
2.2.2 Expansion	13
Appendix A. OWRP Hydraulic Profile	16



Table of Tables

Table 1-1 – Current and Future OWRF Flow Rates	6
Table 2-1 – Failure Criticality Descriptions	7
Table 2-2 – UV System Upstream Water Surface Elevations.....	8
Table 2-3 – Hydraulic Bottlenecks and Potential Remedies	13

Executive Summary

Water Works Engineers (WaterWorks) has conducted an evaluation of the Orem Water Reclamation Facility (OWRF) to identify hydraulic limitations to the facility's ability to meet current and designed buildout flow conditions. The analysis of hydraulic limitations is conducted at Average Annual Daily flows (AAD) and Peak Hour Flows (PHF). The AAD analysis is conducted to identify the typical water surface elevations that the facility will experience on a day-to-day basis. The PHF analysis is conducted to identify the maximum water surface elevations that the facility will experience during peak flow conditions. The flow conditions for the OWRF are summarized below:

Parameter	Current Flow (mgd)	Design Flow at Buildout (mgd)
Average Annual Day Flow (AAD)	8.93	13.5
Peak Day Flow (PDF)	13.6	20.5
Peak Hour Flow (PHF)	21.0	31.7

Hydraulic limitations are identified in accordance with various failures that may occur. These hydraulic failures range from significant failures that result in risk to operator safety or spillage of sewage, to minor failures that result in minor operational inconveniences. The hydraulic failures are classified using a criticality rating in accordance with the following:

- 1 – Minimal Impact Failure – short term failure with minor or no impact on operations.
- 2 – Minor Failure – short term failure resulting in minor disruption to operational performance with no impact on facility's ability to meet discharge requirements.
- 3 – Moderate Failure – short term failure resulting in moderate disruption to operational performance requiring operational modifications to avoid violation of discharge requirements.
- 4 – Significant Failure – short to long term failure resulting in significant impact on facility operations with a high probability of violation of discharge requirements.
- 5 – Serious Failure – Short or long term failure that results in serious impact on facility operations leading to risks to operator safety and/or violation of discharge requirements.

The results of the analysis indicate that the facility is capable of conveying peak flows through the entire treatment train without any overtopping of basins or other catastrophic failures. The following significant hydraulic limitations are identified:

1. UV Disinfection System – Criticality Rating 4

The UV Disinfection System is limited to a flow of 19 mgd without operational modifications conducted by facility staff to maintain operation. The design capacity of the system is 21.6 mgd, which will allow the system to operate at current peak flows but will result in system failures as influent flow to the OWRF increases in the future. Failure of the system results in a complete system shutdown, which is a permit violation for not meeting regulated disinfection requirements.

2. Primary Effluent Pump Station (PEPS) – Criticality Rating 3

The PEPS has sufficient capacity to meet both current and projected design flows. The pump station consists of two separate pumping systems. One of these systems (mixed flow pump system) allows the operation of all three bioreactors with an even flow split. The second pumping system (screw pump system) is only capable of conveying flow to two of the three bioreactors. Facility operators address the limitations created by the screw pump system by only using it in periods of high flow, when the capacity of the mixed flow pump system is exceeded. During high flows, or if one of the mixed flow pumps is out of the service, the screw pump system must be used. The uneven flow split created when the screw pump system is used results in degradation to the bioreactor treatment performance. This degradation may lead to the facility discharging phosphorus at concentrations that exceed the facility's phosphorus limit that is to take effect in 2023. Orem staff will employ a treatment strategy that includes multiple systems to remove phosphorus, so disruption to phosphorus removal in the bioreactors will be addressed with the operation of chemical phosphorus removal. Regular reliance on chemical phosphorus removal requires significant chemical usage and will result in significant operational costs. The OWRF experienced a 22% increase in chemical costs in 2021 alone.

Options to address the hydraulic limitations have been identified for further evaluation as directed by Orem staff. These options include:

1. UV Disinfection System

- a. Expand the capacity of the UV Disinfection System by adding a third channel or replacing the UV equipment with a higher capacity unit.
- b. Add a screening system upstream of the UV Disinfection System to remove debris from the water that exacerbates the hydraulic limitations inherent in the system.

2. PEPS

- a. Expand the capacity of the mixed flow pumping system by modifying the pump station to include additional pumps or replace the existing pumps with higher capacity units.
- b. Replace the PEPS completely with a new pump station designed to meet current facility flows and easily expand to meet future flows.

The options identified may provide short-term benefits to further delay the need for more costly options or eliminate the limitations completely. These options will be evaluated in conjunction with options currently being identified to address process, operational and other limitations.

1 Hydraulic Capacity Analysis

Water Works Engineers (WaterWorks) has conducted a hydraulic analysis of the Orem Water Reclamation Facility (OWRF) to determine the hydraulic capacity of the existing process, identify the location and flow rates at which hydraulic bottlenecks will occur, evaluate their consequences, and recommend upgrades to extend the facility's operational life.

1.1 Hydraulic Model Development

The hydraulic model was developed for the OWRF using record drawings, site investigations, information from facility staff, and a site survey of key hydraulic elements. The model was calibrated by comparing water surfaces predicted by the model with water surfaces measured at key locations within the facility. After calibration the model was used to conduct a hydraulic analysis of the facility by predicting water surfaces throughout the facility at various flow rates. The hydraulic profile of the facility is included in Appendix A. This profile presents the predicted water surfaces in the facility at both current and buildout average annual day (AAD) flow and peak hour flow (PHF). The AAD and PHF flows for this analysis were developed as described in the Flows and Loads Technical Memorandum and are summarized in Table 1-1.

1.1.1 Model Assumptions

The OWRF is typically operated with Bioreactor No. 3 (BNR3) and either Bioreactor No. 1 (BNR1) or Bioreactor No. 2 (BNR2) in service. The model assumes that BNR1 and BNR3 are in service. All clarifiers are also assumed to be in service within the model.

Facility staff have indicated that the primary effluent screw pump station is rarely used. To represent this, the hydraulic model assumes that all primary effluent is pumped to the anaerobic basin influent box associated with BNR3 before being distributed to BNR1 and BNR3.

The RAS rate in the secondary treatment process (from the primary effluent pump stations to the secondary clarifiers) is assumed to be equal to the influent rate (1Q). This is based on the results of process modeling, which determined an optimal RAS rate of 1Q. Because it is not typical to increase the RAS rate during periods of peak flow, a maximum RAS rate equal to 1Q of the PDF rate was used for flows in excess of PDF.

1.1.2 Flow Rate Analysis

WaterWorks was provided historical flow data that indicate a current AAD and PHF rate of 8.93 mgd and 21.03 mgd, respectively. These result in a peaking factor (PHF:AAD) of 2.35. Based on information from the 2016 Orem City Sewer Master Plan (2016 Master Plan), the buildout AAD and PHF rates are estimated at 13.5 mgd and 21.6 mgd, respectively. However, WaterWorks' hydraulic modeling assumes that the current peaking factor remains unchanged as the community grows. Therefore, the projected buildout PHF is estimated to be 31.7 mgd, calculated by applying the current peaking factor of 2.35 to the estimated buildout AAD of 13.5 mgd. These flow rates are summarized in Table 1-1, and water surfaces associated with the AAD and PHF flow scenarios is described in the hydraulic profiles in Appendix A.

Current and future flow data are discussed in greater detail the Flows and Loads Technical Memorandum.

Table 1-1 – Current and Future OWRF Flow Rates

Parameter	Flow Factor	Current Flow (mgd)	OWRF Design Flow (mgd)
AAD	1.00	8.93	13.5
PDF	1.52	13.6	20.5
PHF	2.35	21.0	31.7

1.2 Hydraulic Model Calibration

WaterWorks created a hydraulic model of the OWRF. After the model was initially developed, a site survey was performed by WaterWorks and the OWRF's onsite GIS specialist to accurately capture weir and top of wall elevations throughout the facility. Using these benchmarks, water surface elevations were gathered at both high-flow and low-flow periods of the day, during which stable influent rates could be expected. This data was used to verify and calibrate the hydraulic model.

The calibrated model was then used to identify hydraulic bottlenecks in the facility's liquid stream process. The model results and hydraulic bottlenecks identified are used to develop recommendations for facility upgrades and modifications that will improve facility hydraulics.

2 Failure Criticality

The hydraulic model was used to identify locations within the facility that experience hydraulic limitations at current and projected flow rates. Each limitation is identified and classified according to the relative impact it will have on facility operations, including the ability to meet permit, possibility of damage to equipment, operator safety, and possibility of sewage spillage. Failure criticality has been ranked from 1 to 5 with the following interpretations:

Table 2-1 – Failure Criticality Descriptions

Criticality	Description
1	Minimal Impact Failure – Results in minor, short term disruption to process performance with very low probability of permit violation or other impact.
2	Minor Failure – Results in minor disruption to process performance for an extended duration, or loss of process control for a short duration, with very low probability of permit violation or other impact
3	Moderate Failure – Results in moderate, short term impact to process performance and/or loss of operational control requiring the use of alternative process controls and measurement. Low probability of permit violation.
4	Significant Failure – Results in significant, long term disruption to process performance with high probability of a permit violation.
5	Serious Failure – Results in unsafe conditions, sewage escaping hydraulic structures, or damage to equipment and/or facilities.

2.1 Hydraulic Analysis – Liquid Stream Process Units

A hydraulic analysis of the liquid stream process units has been conducted to evaluate and identify the maximum process water flows that can be conveyed through the OWRF without experiencing hydraulic limitations. The criticality of each hydraulic failure has been classified as outlined above.

The flows analyzed range from the current AAD flow to the projected buildout PHF rate as described in Section 1.1.2.

2.1.1 Ultraviolet Disinfection

The ultraviolet disinfection (UV) system was installed at the OWRF in 2013 and consists of two channels equipped with three UV modules each. The system was designed for a peak hour flow of 21.6 mgd, as described in the 2016 Master Plan. Operators report having difficulties with the UV system beginning at approximately 19-20 mgd, and during a recent high flow event where peak flows of 26 mgd were observed, the system shut down.

The UV disinfection system is equipped with a level switch designed to prevent water surfaces from rising to levels that will result in damage to the UV modules installed in each channel. The design maximum water depth is 62 inches (a water surface elevation of 4,499.33), as indicated on the manufacturer's design drawings. The bottom of the UV modules is set at an elevation of 4,500.17 feet. The exact set point of the flow switch is unknown, but at flow rates between 19 mgd and 21.6 mgd, the water surfaces predicted by the calibrated hydraulic model are significantly higher than the design maximum water surface, and within four inches of the entering the electrical portion of the UV modules of the UV system modules (see Table 2-2). If the water surfaces in the channel are not completely quiescent, operational difficulties may result at these water surfaces. The maximum water surface at 26 mgd are just above the electrical portion of the UV modules, which suggests the UV system would have

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been shut down by the time this flow rate occurred to prevent equipment damage, which is consistent with operator reports.

Table 2-2 – UV System Upstream Water Surface Elevations

Flow Rate (mgd)	Water Surface Elevation (feet) (Distance from the Electrical Portion of the UV module (inches))
19	4,499.86 (3.72)
20	4,499.91 (3.12)
21.6 (design maximum flow rate)	4,499.98 (2.28)
26	4,500.19 (-0.24)

Operational difficulties and the potential for UV system shutdown at flows in excess of 19 mgd represents a significant system failure that is likely to occur at current peak flow rates. Based on the criticality scale established in Table 2-1, the criticality of this hydraulic limitation is rated as a 4 since it does have the potential to create a significant process upset and result in a permit violation.

In addition to the hydraulic limitations inherent in the system design, the operations staff have witnessed debris that enters the wastewater upstream of the UV system becoming caught on the UV lamps. This debris has been seen to build up within the UV lamps causing increased hydraulic losses through the UV system. In addition to hydraulic losses, the debris has also cause physical damage to the crystals and UV bulbs due to breakage. This operational challenge further limits the hydraulic capacity of the UV system beyond the hydraulic limitations discussed above. This problem is currently addressed by removing the debris from the UV system weekly. Possible solutions are covering the upstream basins where debris is currently entering the system, or providing a screening system to prevent the debris from entering the UV system. These options will be further evaluated in coordination with options identified to meet the hydraulic limitations.

The level switch in the channel may be set to a higher set point to address the UV system hydraulic deficiencies in the short term. This must be done in coordination with the manufacturer to ensure that the flow switch set point is set at a level that maintains the proper operation of the system and provides the appropriate equipment protection.

The UV system will have to be expanded to address the system's inherent hydraulic limitations. This may be accomplished by modifying the existing system or by adding a third channel to supplement the existing system. Either of these options will address the hydraulic constraints identified in this study and will be evaluated further.

The UV system was provided with capacity in each channel for installation of a fourth module to expand its disinfection capacity. However, due to concerns about increased head losses, installation of a fourth

module is not recommended unless modifications are made in coordination with the system manufacturer to address the hydraulic capacity of the channels as previously discussed. The treatment capacity of the UV system will be evaluated in the Process Evaluation Technical Memorandum.

2.1.2 Parshall Flume (Effluent Flow Measurement)

A parshall flume is located upstream of the UV disinfection system to provide flow measurement. The flume has a 24 inch throat width, which is suitable for measurement of flows up to 21.4 mgd. This flume is suitable for flow measurement at current flow conditions up to the PHF.

For the projected buildout flow conditions, rates above the PDF rate exceed the range for accurate flow measurement. Replacing the 24 inch Parshall flume with one with a 36 inch throat width will allow flows to be measured up to 32.2 mgd, which exceeds the projected buildout flow rate of 31.7 mgd.

The limitations of the Parshall flume do not inhibit the proper hydraulic operation of the OWRF. However, accurate flow measurement is a reporting requirement for the facility's UPDES permit. In the short term, these peak flows are an infrequent occurrence, but may occur more frequently as Orem continues to grow. The criticality of this hydraulic deficiency is rated as a 2 since it does have the potential to create a minor process disruption and is unlikely to cause a permit violation.

2.1.3 Bioreactors

The OWRF process consists of three extended aeration bioreactors. Bioreactor 3 (BNR3) was added to the process in 2010 and includes anaerobic zones for BNR1 and BNR2 to support biological phosphorus removal. Primary effluent is delivered to the BNR3 influent box by the primary effluent mixed flow pumps. OWRF staff typically operate BNR3 and either BNR1 or BNR2. They have operated all three bioreactors simultaneously in the past but have found that for current facility loads, the process is easier to control with only two bioreactors operated at a time.

At the current and projected PHF for the OWRF, flooding of the BNR1 or BNR2 anaerobic zone effluent weir is predicted. Flooding of this weir was accepted in the hydraulic design created for the biological upgrade project completed in 2010 and is not considered a failure. However, operators may find it necessary to begin using all three bioreactors to improve facility performance as flows to the facility increase over time. It is not uncommon for treatment facilities to have excess capacity in their secondary treatment processes without having a fully redundant treatment train. However, OWRF staff prefer not to use all three bioreactors because having a fully redundant bioreactor system is convenient for performing routine repairs and maintenance. Using all three bioreactors would limit maintenance to periods of lower flow when removing one bioreactor from service would not place undue stress on the treatment process.

Alternately, if the OWRF staff continue to find that sufficient treatment capacity is provided by operating only two of the three bioreactors, they may continue to operate BNR1 or BNR2 in a duty standby configuration, using the standby bioreactor for emergency surge overflow during peak flow events. This may be achieved by opening the gate to the anaerobic basin for the standby bioreactor during periods

of very high flow, allowing a portion of the flow to fill the standby bioreactor and minimizing the hydraulic stress on downstream processes.

After a peak flow event subsides, the water in the standby/surge bioreactor may be drained and routed back to the headworks facilities. Draining the water in the standby/surge bioreactor after a surge event removes a portion of the mixed liquor biology required for secondary treatment. This may have a negative impact on bioreactor performance for a period of time following a peak event. If peak events are infrequent, this may be acceptable. If not, Orem may elect to retrofit the bioreactors with a pumping system to allow mixed liquor to be returned to the duty bioreactor rather than drained and routed to the headworks.

The criticality of the weir flooding at BNR1 or BNR2 is rated as a 1 since it does not create the potential for a significant operational disruption or permit violation.

2.1.4 Primary Effluent Pump Stations

The OWRF has two primary effluent pump stations (PEPS). The main PEPS is equipped with three mixed flow pumps. This pump station has a firm rated capacity of 17.5 mgd with the pumps operated in a two duty, one standby configuration. However, all three pumps are routinely used, so the pump station lacks a standby pump. The pump station's total capacity is 26.3 mgd, as operated, with all pumps in service. The mixed flow PEPS conveys primary effluent and RAS to the anaerobic zone influent box adjacent to BNR3. A portion of this flow passes over a weir and is routed to the BNR3 anaerobic zone. The remainder flows over a weir gate, used to maintain the desired flow split between the bioreactors, and through a pipe to the anaerobic zone influent box associated with BNR1 and BNR2.

The second PEPS is equipped with three screw pumps in a two duty, one standby configuration. The screw pump PEPS has a rated firm capacity of 22.8 mgd and a total capacity of 34.2 mgd with all pumps in service. It is designed to convey primary effluent and RAS directly to the splitter box for BNR1 and BNR2 anaerobic zones. The screw pump station is not capable of conveying flow to the influent box for BNR3, so it is not capable of feeding BNR3. Due to this operational limitation, this pump station is used as a standby pump station to the mixed flow pump station and is only operated when the capacity of the mixed flow pump station is exceeded. The total combined capacity of the two pump stations is 49.1 mgd with all mixed flow pumps and two screw pumps in operation, or 60.5 mgd with all mixed flow and screw pumps in operation. This capacity is sufficient to meet buildout PHF at a RAS flow rate equal to PDF (1Q of PDF), see Section 1.1.1.

The hydraulic capacity of the mixed flow PEPS, with all three pumps placed in service, is capable of meeting current flow conditions, depending on the desired RAS rate. Process modeling suggests that biological treatment is optimized at a RAS flow rate equal to the influent rate, 1Q, up to a maximum of 1Q of PDF. Under current conditions, the mixed flow PEPS can meet the AAD condition with 1Q RAS flow and the the PDF condition at a slightly lower RAS rate, 0.93Q RAS flow. The hydraulic capacity of the pump station is also sufficient to meet the buildout AAD at 0.95Q RAS flow. As the flow increases, however, the pump station is insufficient to deliver mixed liquor to the bioreactors at a desirable RAS flow rate, or to even achieve the buildout PHF condition. Under these conditions, it is necessary to

operate the screw pump station, which allows both current and future flow conditions to be met, albeit without adequate redundancy at buildout PHF.

Because the mixed flow pump station is already being operated with all three pumps in service, the plant already has a significant maintenance issue due to a lack of redundancy in primary effluent pumping. This lack in redundancy is partially addressed by the screw pump station, but the screw pump station presents an operational challenge because it is not capable of conveying flow to BNR3. This results in an uneven flow split between the bioreactors during high flows when the capacity of the mixed flow pump station is exceeded. This uneven flow split has the potential to negatively impact the performance of the treatment system resulting in degraded nutrient removal, which may result in violation of the City's discharge permit for phosphorus if other operational strategies to remove phosphorus are not employed.

The OWRF also lacks adequate control and monitoring capabilities for their RAS pumping system, which also has the potential of negatively impacting the plant's treatment performance. Although the primary pumping system does not create a hydraulic limitation, the operational limitations of this system do have the potential to result in a process related permit violation. The City is taking steps to develop a strategy for meeting the phosphorus limit that includes multiple phosphorus removal systems, but this strategy has not been fully implemented. Noting the maintenance and repair risk presented by a lack of redundancy in the mixed flow pump station, the current risk of a permit violation and that this risk may be addressed with the use of alternate processes, this hydraulic/operational limitation is assigned a criticality rating of 4.

At current flows, the facility addresses this operational limitation by operating all three mixed flow pumps during high flow periods. This allows the operations staff to control the flow split between the three reactors to meet their treatment objectives. When facility influent rates exceed the capacity of the mixed flow pump station, or when one of the mixed flow pumps is out of service for maintenance or repair, operators place the screw pump station in service. This allows the facility to meet the hydraulic capacity requirements but results in the degradation to performance discussed above.

This hydraulic/operational deficiency can be addressed by expanding the capacity of the mixed flow pump station. This may be achieved by replacing some (or all) of the existing pumps with higher capacity pumps or modifying the pump station to allow a fourth pump to be installed. Modification of the screw pump station to allow it to convey flow to BNR3 will require the complete reconstruction of the pump station and replacement of all of the screw pumps due to the fact that they were originally installed in 1983 and are at the end of their useful life. This is, therefore, not expected to be a feasible option.

2.1.5 Primary Clarifiers

In the development of the hydraulic model, it is assumed that the primary effluent pump stations are operated at the design maximum wetwell water surface elevation of 4,502.75 feet. At this water surface elevation, flow rates in excess of 23 mgd result in flooding of the weirs at primary clarifiers 3 and 4, and flow rates in excess of 24 mgd result in flooding of the primary clarifier splitter box. However, facility staff have indicated that during high flow periods they are able to prevent this from happening by

operating the primary effluent pumps to maintain a water surface in the wetwell that is below the maximum water surface setpoint. As long as there is sufficient pumping capacity in the primary effluent pump station, flooding of these weirs will not occur. In addition, the flooding of these weirs does not create a hydraulic limitation and is a relatively minor operational issue. The criticality of this limitation is rated as a 1.

If operational difficulties result from this limitation, the effluent weirs in primary clarifiers 3 and 4 may be raised to an elevation of 4,504.25 feet or higher to prevent the weirs from flooding.

2.1.6 Headworks Effluent Flume

The OWRF headworks effluent weirs are each 11 feet, 3 inches long and set at an elevation of 4508.98 feet. These weirs begin to be flooded at flow rates exceeding 16.5 mgd. This agrees with the observations of facility staff, who did not have recorded data indicating when these weirs begin to flood but estimated the flow rate at which it occurs to be approximately 15 mgd. This is consistent with hydraulic modeling associated with the 2010 bioreactor design and does not represent a serious hydraulic limitation. The only option for preventing this from occurring is to modify the headworks effluent channel with a weir placed at an elevation of 4510.50 feet. This change will accommodate buildout PHF without flooding. This modification will also raise the water surface elevation between the Palmer Bowlus influent flow measurement flume to the headworks effluent weir, which will negatively impact operation of the headworks. Periodic flooding of this weir poses no hydraulic or operational concern. The most significant limitation of the headworks facility is that it lacks redundancy, so OWRF staff are unable to take down a channel for maintenance. A failure of equipment at the headworks facilities may result in collection system flooding if the failure prevents flow. The only option to address this deficiency is to expand the headworks facilities to include redundancy. This limitation is assigned a criticality of 3.

2.1.7 Plant Influent Pipe

The 2016 Master Plan indicates that pipes in the collection system are considered at capacity when they are 75% full, which occurs when the water level in the pipe is approximately 65% of its diameter. At buildout AAD and PHF flow conditions, the water surface in the influent pipe will be 75% and 90% of the pipe diameter respectively. This is not something that can be addressed by improvements or modifications at the OWRF but should be considered in the planning and operation of the collection system.

2.2 Hydraulic Bottlenecks

The hydraulic limitations identified and discussed above have been evaluated to identify the hydraulic features that will represent the greatest risk of failure. Options have been identified to address each of these hydraulic bottlenecks with the objective of increasing the facility's hydraulic capacity to accommodate the buildout peak flow conditions projected for the OWRF. The extent that the capacity of the facility can be extended by each option identified is dependent on how each option is implemented in the design stage.

2.2.1 Current Capacity

The current capacity of the facility is the capacity associated with the UV disinfection system. This system was designed for a buildout PHF capacity of 21.6 mgd. However, facility staff have indicated that when flows reach 19 to 20 mgd, they experience operational difficulties. Since the proper operation of the UV facility is critical to the facility's ability to meet its discharge permit, the capacity of the facility is limited by the capacity of the UV system. Based on this, the OWRF's capacity is limited to a peak flow of approximately 19 mgd, which is associated with a rated annual average flow of 8.3 mgd. The OWRF is currently experiencing flows in excess of this capacity and the hydraulic limitation is addressed by operational modifications made by operations staff during high flow periods. Considering the design limitations of the UV facility, facility operators will not be able to address the hydraulic limitations when peak flows exceed 21 mgd, or an average annual flow of approximately 9.1 mgd. As has been seen in the operation of the UV system, flows in excess of 21 mgd will result in UV system failure, resulting in the facility's inability to meet the required discharge permit for disinfection.

2.2.2 Expansion

Table 2-3 lists the hydraulic bottlenecks identified in this study that limit the facility's ability to reach the desired peak hour build-out capacity of 31.7 mgd. Each hydraulic bottleneck is listed with the flow at which the hydraulic limitation occurs. Criticality assigned to each bottleneck is taken from the discussion of criticality presented above. A list of potential remedies is also presented.

Table 2-3 – Hydraulic Bottlenecks and Potential Remedies

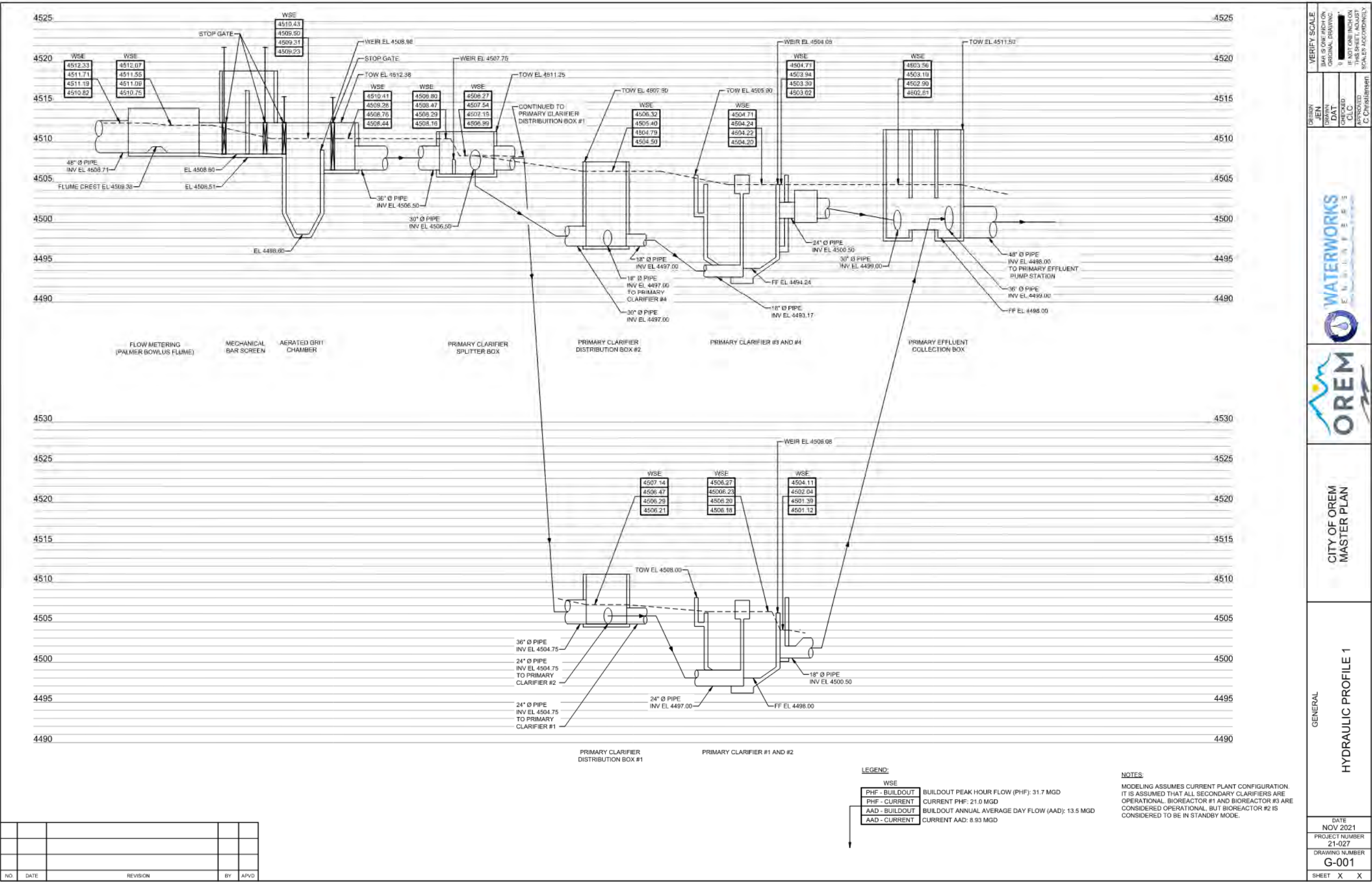
Bottleneck(s) Identified	Flow at Failure (mgd)	Criticality	Potential Remedies
UV Disinfection System	19 - 21	4	- Expand the UV system by installing a third UV channel or otherwise expanding the treatment and hydraulic capacity of the current system. - The provision of a screen system will aid the operations staff in maximizing the capacity of the UV system and minimize operational upsets and equipment damage for the short term, but it will not address the long term capacity deficiencies.
Parshall Flume for Effluent Flow Measurement	21.4	2	Upgrading to a flume with a 36 inch throat width will increase the flow measurement capacity to accommodate buildout PHF conditions, up to 32.6 mgd.
Bioreactors	21.0 (flooding of anaerobic zone effluent)	1	No modification is required to ensure proper hydraulic performance. If the process becomes impaired as buildout flows are approached, improved performance can be achieved by operating all three bioreactors concurrently.

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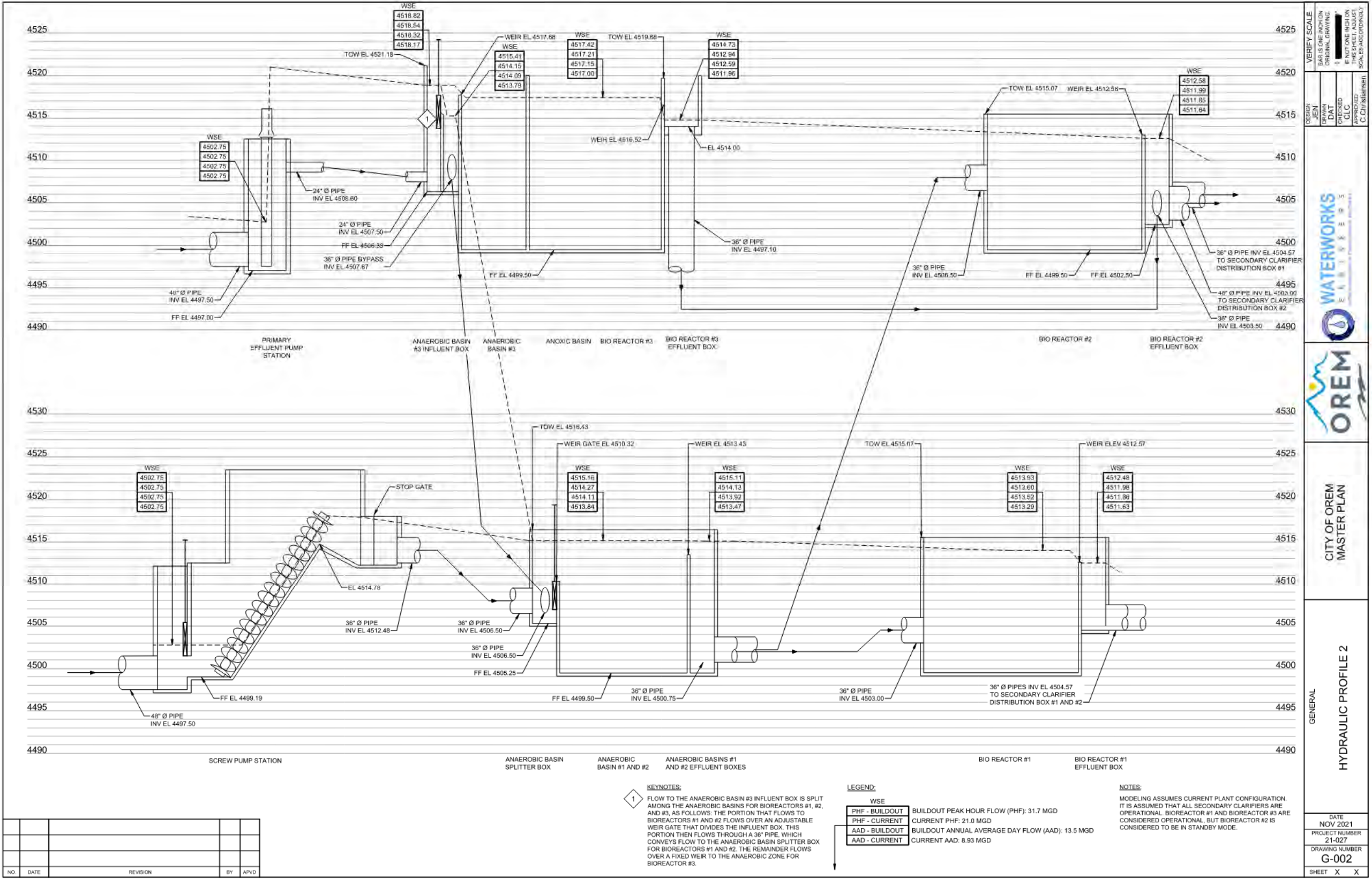
Bottleneck(s) Identified	Flow at Failure (mgd)	Criticality	Potential Remedies
	weir occurs)		○ When periodic maintenance or repairs are required, it may be necessary to take down bioreactors during periods of sustained low flows. ● If three bioreactors are not required for improved hydraulic performance during PDF conditions, the plant may employ measures to use the standby bioreactor for surge flow during peak events. ○ Surge flows to be drained and routed to the head of the plant after peak events. This will impact mixed liquor concentrations for a period after peak events. ○ Alternately, bioreactors may be retrofitted with pumps to return surge flow to the duty bioreactor so mixed liquor biology may be preserved.
Primary Effluent Pump Stations (PEPS)	Mixed Flow Pump Firm Capacity: 17.5 Screw Pump Firm Capacity: 22.8 Total PEPS Firm Capacity: 40.3	4	● Expand the capacity of the mixed flow pump station by replacing the pumps with higher capacity units or modifying the pump station to allow the installation of additional pumps. ● Replace the PEPS in its entirety with a new pump station designed with a firm capacity of approximately 31 mgd.
Primary Clarifiers 3 and 4	23	1	● Continue operational control measures by maintaining the water surface in the PEPS wetwell below the maximum design elevation of 4,502.75 feet at high flows. ● Raise the weirs in primary clarifiers 3 and 4 to a weir elevation of 4,504.25 feet
Headworks	16.5	3	● Redesign the effluent channel with weirs set at 4,510.50 feet

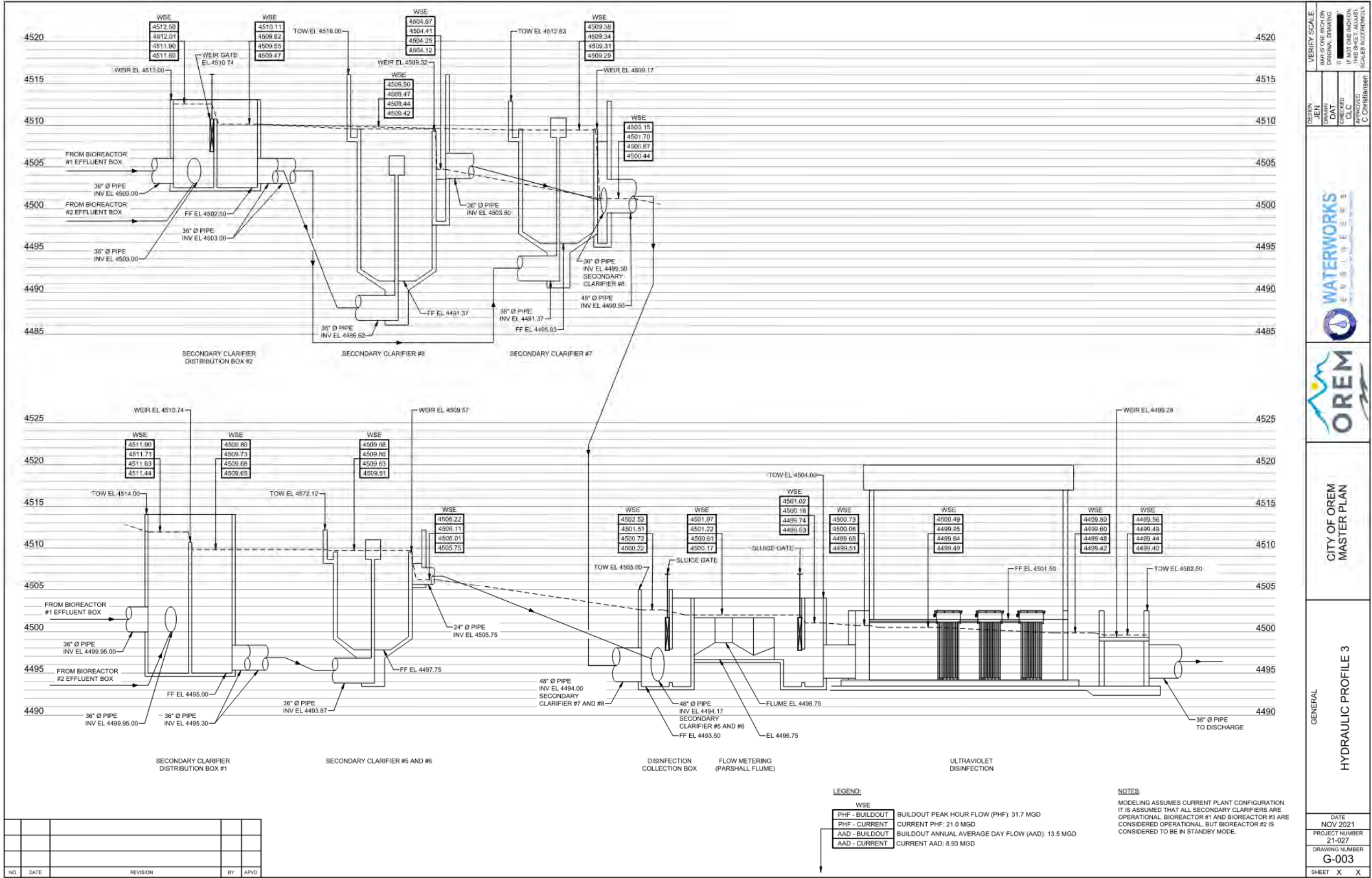
Bottleneck(s) Identified	Flow at Failure (mgd)	Criticality	Potential Remedies
			Headworks facilities may be expanded with redundancy.

Appendix A. OWRF Hydraulic Profile



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APPENDIX C. **Treatment Process Evaluation Memorandum**



OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
TREATMENT PROCESS EVALUATION MEMORANDUM

OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
TREATMENT PROCESS EVALUATION MEMORANDUM

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Table of Contents

Executive Summary.....	3
Introduction	5
1. Performance Criteria.....	5
1.1 Nutrient Performance Criteria	5
1.2 Per- and Polyfluoroalkyl Substances (PFAS)	6
2. Treatment Process Model Calibration	7
2.1 General.....	7
2.2 Treatment Process Schematics	8
2.3 Modifications and Assumptions in the Process Model	10
2.4 Winter and Summer Month Calibrated Model.....	13
3. Capacity of the Treatment Process at Average Day Maximum Month (ADMM) Load and Design flow	16
4. Existing Treatment Process Optimization and Improvement.....	19
4.1 Ammonia Based Aeration Control (ABAC)	19
4.2 RAS Flow Control.....	22
4.3 Aluminum Sulfate Dosing location.....	22
5. Treatment Process Options	23
5.1 Carbon Limitation	23
5.2 Treatment Alternatives to Address Carbon Limitation.....	23
5.3 Side stream Phosphorous Removal	25



6. Summary of Process Modification and Treatment Options	30
7. PFAS Treatment	32
7.1 Physical Adsorption/Separation Technologies for PFAS Removal.....	32

Table of Figures

.....	
Figure 1 Current Orem Water Reclamation Facility Treatment Process Schematics	9
Figure 2 Typical ABAC Process Schematic.....	21
Figure 3 Single Stage Primary Sludge Fermenter/Thickener Schematics	25
Figure 4 Ovivo's Elovac Schematics	28
Figure 5 Centrisys's Magprex (previously known as Airprex) Schematics.....	29

List of Tables

Table 1 Effluent Limit based on UPDES permit and anticipated requirements	6
Table 2 Thermophilic Digester Model Kinetic Parameters	12
Table 3 Assumed Aluminum Dose at Facility Feed Locations.....	13
Table 4 Comparison of Winter (January to March) Calibrated Model	13
Table 5 Comparison of Summer (July to September) Calibrated Model.....	15
Table 6 Predicted Treatment Process Performance at Design Flow and ADMM Load	17
Table 7 Predicted Process Performance at Design Flow and ADMM Load with Biosolids Thickening	18
Table 8 Performance of Calibrated Winter (January to March) model With and Without ABAC.....	20
Table 9 Summary of Process Modification and Treatment Options	30

Executive Summary

A calibrated BioWin model was developed to model the Orem Water Reclamation Facility's (OWRF) performance based on observations and facility data collected during the winter and summer months of 2020. The model was calibrated to produce results within 0-5% of observed performance for key parameters, and within 10% of actual performance for less critical parameters.

Using the process model, the following process optimization and improvement options were identified as preferred options for the enhancement of the facility's biological treatment performance:

- Ammonia Based Aeration Control (ABAC)
- Return Activated Sludge (RAS) Flow control
- Aluminum Sulfate (Alum) Feed in the Belt Filter Press Feed

Based on ABAC and RAS flow control modeling results, these strategies will significantly improve the phosphorous removal performance at the OWRF, but the improvement is not expected to be sufficient to meet the facility's total phosphorus (TP) effluent limit.

Alum feed is currently being conducted in three locations within the facility for phosphorus removal. Based on experience and phosphorous dosing chemistry, alum feed to the belt filter press feed is the most effective location and will result in the most efficient phosphorus removal if chemical phosphorus removal is required to meet the effluent limit after improvements to the biological process are completed.

These process optimization options were identified as relatively inexpensive modifications that can be implemented in a relatively short time period.

In addition to the evaluation of the process modifications discussed above, treatment process alternatives were evaluated to identify strategies that are capable of meeting the current and anticipated discharge limits at current and projected buildout flows. These strategies were identified to address process limitations identified through the use of the calibrated process model. The key limitations to the OWRF's ability to meet the treatment objectives include:

- Insufficient carbon available to support the organisms that perform phosphorus and nitrogen removal
- Excessive recycle of phosphorus and ammonia in the return streams from the biosolids processing and dewatering systems

The following alternative treatment options have been evaluated for their ability to address these limitations, allowing the OWRF to meet current TP effluent limits and anticipated total inorganic nitrogen (TIN) effluent limits under the current and future flow and load conditions:

- Carbon supplementation strategies in the mainstream treatment process
 - Partial bypass of primary influent to the bioreactors
 - Primary sludge fermentation
 - Chemical carbon addition
- Sidestream phosphorous and ammonia removal:
 - Post aerobic digestion (PAD)

- o Struvite precipitation
- o Continued alum addition

Modeling of these treatment options in conjunction with ABAC and RAS flow control was performed to check their combined impact on the OWRF treatment process and the resultant facility's ability to meet current and anticipated future effluent discharge requirements. These analyses indicated that various combinations of these strategies are capable of meeting the treatment objectives. These strategies will be further evaluated with City staff to identify operational, performance, and cost preferences and a preferred strategy and implementation schedule will be developed.

Treatment options for removal of PFAS from wastewater were also evaluated. Treatment to remove PFAS is in its early stages of development in the wastewater industry. Current removal strategies such as adsorption and separation are expensive and have been found to be moderately effective in the removal of PFAS from the liquid stream. The long-term efficacy of these strategies is currently in question because they do not destroy PFAS compounds, but rather create a concentrated PFAS waste stream that must be further treated. PFAS destruction technologies include oxidation and incineration technologies. These strategies are under investigation, but there is not current indication that a destruction technology will be developed that is affordable within the wastewater treatment facility. PFAS is not produced in Utah and is used in very few industrial processes. It is recommended that a survey be conducted to identify industrial users that utilize PFAS in their production process. Destruction of PFAS at the source is expected to be for more economical than treatment within the OWRF.

Introduction

This memorandum presents the treatment process evaluation of the existing Orem Water Reclamation Facility (OWRF), and evaluation of process alternatives for enhanced nutrient removal. The memorandum discusses various process modifications to identify the optimum process design for various flow, load, and regulatory scenarios. The flows and loads developed in the *Flows and Loads Technical Memorandum* are used for the evaluations conducted herein.

1. Performance Criteria

1.1 Nutrient Performance Criteria

OWRF's Utah pollutant discharge elimination system (UPDES) permit, approved on April 19, 2021, was reviewed for current and anticipated future effluent limits. Table 1 summarizes OWRF's effluent criteria, which will remain in place until April 18, 2026.

Utah Administrative Code rule R317-1-3.3 details Utah State's Technology based Phosphorus Effluent Limit (TBPEL), which requires wastewater effluent to reach an annual average effluent total phosphorus (TP) concentration of 1.0 mg/L. The OWRF was granted a variance to this requirement until January 1, 2023, that assigns an interim annual average effluent TP concentration of 2.5 mg/L.

OWRF staff have requested that the treatment process also be evaluated for total inorganic nitrogen (TIN) removal capacity and for upgrade recommendations to meet an anticipated effluent TIN limit of 10 mg/L. It is unclear whether TIN limits will be monitored on an annual, monthly, or rolling average. Nutrient limits currently in place for facilities in Utah have utilize annual geomeans, annual and seasonal averages, and total loading limits.

This memorandum will evaluate the process optimization required and suggest alternative processes to meet the current and anticipated effluent limits.

Table 1 Effluent Limit based on UPDES permit and anticipated requirements

Parameter	Effluent Limitations	
Total Flow (mgd)	13.5	
Biochemical Oxygen Demand (BOD ₅) (mg/L)	25 (maximum monthly) 35 (maximum weekly average)	
BOD ₅ (mg/L) min % removal	85	
Total Suspended Solids (TSS) (mg/L)	25 (maximum monthly) 35 (maximum weekly average)	
TSS (mg/L) min % removal	85	
Dissolved Oxygen (DO) (mg/L)	5.5 (daily minimum)	
Total Ammonia (mg/L as N)		
Summer (July to September)	3 (maximum monthly)	11 (daily maximum)
Fall (October to December)	4 (maximum monthly)	15 (daily maximum)
Winter (January to March)	5 (maximum monthly)	19 (daily maximum)
Spring (April to June)	4 (maximum monthly)	14 (daily maximum)
Interim TP effluent limit (mg/L) until December 31, 2022	2.5 (yearly average)	
TP effluent limit effective on January 1, 2023 (mg/L)	1.0 (yearly average)	
E. Coli (Number/10 mL)	126 (maximum monthly) 157 (maximum weekly average)	
Oil & Grease (mg/L)	10 (daily maximum)	
pH (standard units)	6.5 (daily minimum) 9 (daily maximum)	
Anticipated TIN (mg/L)	10	

1.2 Per- and Polyfluoroalkyl Substances (PFAS)

The United States Environmental Protection Agency's (EPA) is undertaking efforts to study and regulate PFAS in water and wastewater treatment systems. To address the possibility of future PFAS regulations, OWRF staff have requested a PFAS investigation and process evaluation.

The EPA is currently studying methods to detect and measure PFAS more efficiently in wastewater and biosolids. The efficacy of PFAS removal in wastewater facilities is largely unknown. The EPA is working to evaluate the potential for management and disposal of PFAS through wastewater treatment.

The Utah department of Water Quality (DWQ) PFAS workgroup, established in Spring, 2019, published a reconnaissance plan in April 2020 and a sampling and analysis plan in October 2020, but does not comment on PFAS regulation. Based on the sampling and analysis plan results, more information will become available regarding PFAS regulation.

Section 7 discusses some of the candidate technologies for PFAS treatment specifically related to controlling PFAS in wastewater and in biosolids.

2. Treatment Process Model Calibration

2.1 General

It is critical to model the complete treatment process accurately and calibrate the model to observed performance in the evaluation of the OWRF's existing process and development of recommended process alternatives. As a starting point for Water Works Engineers' calibration efforts, OWRF staff provided a treatment process model, configured in EnviroSim's Biowin, which was developed by another consultant. The following information, from the *Required Information Memorandum*, was used to update the model in EnviroSim's current version, Biowin 6.2.

- Facility Design drawings from *Water Reclamation Facility 2010 Upgrade* and *Water Reclamation Facility 2013 UV Disinfection*.
- Aerobic Digester capacity Survey.
- Monthly Operating Reports (MOR).
- Waste Activated Sludge (WAS) log.
- HACH WIMS data.
- Solid's stream VSS and TSS measurements data.
- Process Evaluation completed by Carollo Engineers in 2018.

Additionally, the following inputs from the OWRF staff were considered in model calibration:

- TP measured in the influent and evaluated at the OWRF laboratory is higher than the TP measured in a similar sample and evaluated at the certified laboratory. The frequency of sample analysis for TP from the certified laboratory is much lower than those obtained by OWRF laboratory analysis. OWRF staff recommended using the certified laboratory results.
- The grit removal unit is equipped with a grit washer.
- All the primary clarifiers are utilized. The primary sludge flow and concentration are not measured.
- Bioreactor 3 (BNR3) is always in operation. Either Bioreactor 1 (BNR1) or Bioreactor 2 (BNR2) are operated in parallel with BNR3.
- It is difficult to control and measure the return activated sludge (RAS) flow with the existing system. Due to this, the RAS flow split is unknown. Also, OWRF staff have indicated that RAS flow measurement accuracy is questionable.
- Mixed liquor recirculation from BNR3 to the anoxic basin is unknown. But one pump operates at 60 Hz and the other pump operates at 45 Hz. If pump curves for the mixed liquor pumps can be obtained, recirculation rates can be better reflected in the modeling.
- Only three secondary clarifiers of four available are operated. Typically, both of the larger clarifiers (Clarifiers 7 and 8), and one of the smaller clarifiers (Clarifiers 5 or 6) are in operation at any given time.
- One thermophilic and two mesophilic digesters are operated in series. The primary mesophilic digester is mixed continuously, and the secondary mesophilic digester is mixed intermittently.
- Aluminum sulfate (alum) is added at the headworks and before the belt filter press. Occasionally alum is added to the filtrate from the belt filter press for effluent TP control

-
- The aerobic digester is primarily used as a sludge holding tank. It is mixed for a couple of hours at the beginning of the day (usually around 2:00 AM). The capacity of the digesters to provide sufficient dissolved oxygen levels in the aerobic digesters is limited by their available blower capacity.

2.2 Treatment Process Schematics

Figure 1 represents the current flow schematic used in the process modeling effort.

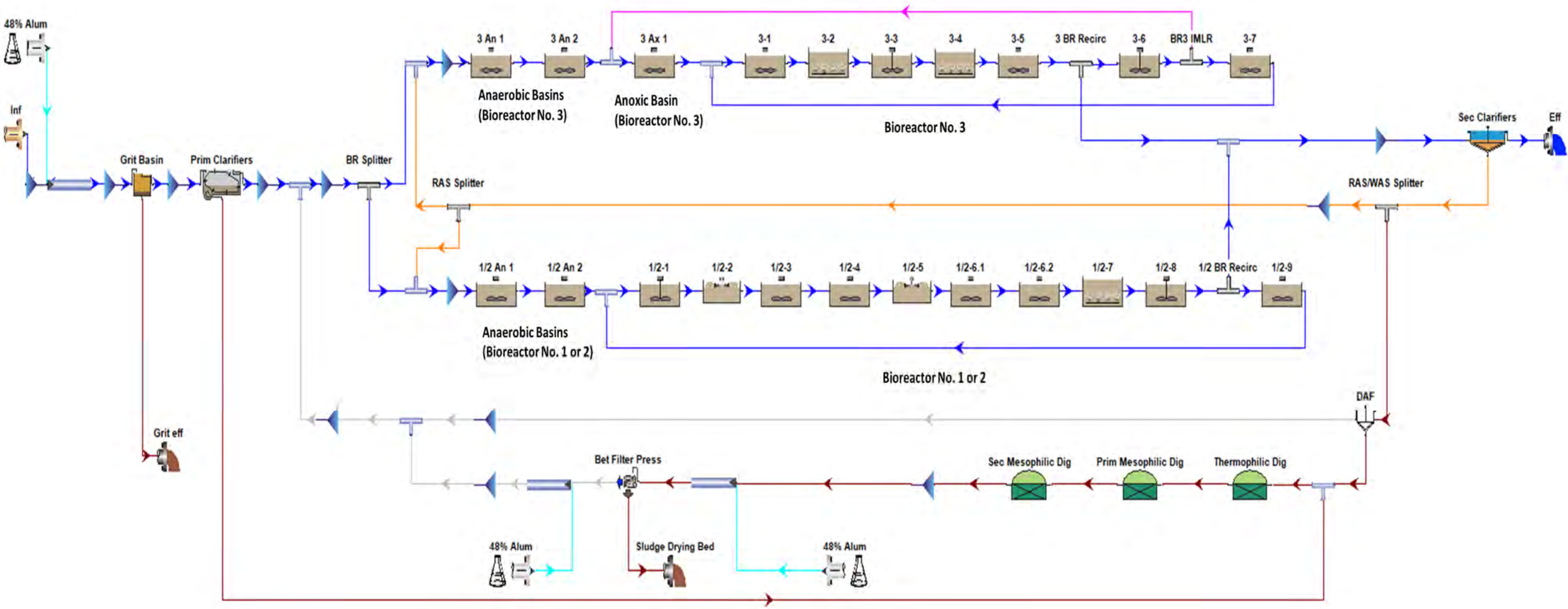


Figure 1 Current Orem Water Reclamation Facility Treatment Process Schematics

2.3 Modifications and Assumptions in the Process Model

Complete operational data for the year 2020 was available for use in the calibration of the process model. Due to seasonal temperature and operational differences at the OWRF, the model was calibrated for both winter months (January to March) and summer months (July to September). The following modifications and assumptions were made in the modelling effort to calibrate the model to reflect the actual facility performance as closely as possible.

- As previously discussed, the influent TP concentrations measured at the OWRF laboratory are significantly higher than the influent TP concentration measured at the certified laboratory. The reason for the difference is not clear, but the results from the certified laboratory are assumed to be more accurate since they utilize superior equipment and a more robust analysis protocol. OWRF staff provided TP results from the OWRF laboratory and the certified laboratory for comparison. A relatively consistent ratio of 1.7 was observed between the OWRF laboratory and certified laboratory results. Since only 5% of the collected influent samples were sent to the certified laboratory for TP analysis there is insufficient certified TP data for use in model calibration. To address this, the TP data collected from TP analysis at the OWRF was reduced by a factor of 1.7 and used in the model calibration analysis.
- As discussed in the *Flows and Loads Technical Memorandum*, an ammonia to total Kjeldahl Nitrogen ($\text{NH}_3\text{:TKN}$) ratio of 0.8 is assumed based on conditions experienced at other nearby treatment facilities. Thus, the default value of fraction (F_{na}) for raw sewage was modified from 0.66 to 0.8 in the Chemical Oxygen Demand (COD) fractionation of the model.
- Alkalinity and pH are not measured in the influent. Thus, an alkalinity of 22 mmol/L and pH of 7.5 were assumed to match the observed effluent pH and digester pH.
- Based on sampling data from a previous study, an influent ratio of volatile to total suspended solids (VSS: TSS) of 0.85 was utilized.
- The default Biowin 6.2 COD fractionation for typical 'Raw Sewage' was used.
- The average winter temperature (January to March 2020) is 14.0°C and the average summer temperature (July to September 2020) is 22.4°C. Temperature has a strong impact on biological activity and reaction kinetics, which in turn affects facility operational parameters such as dissolved oxygen (DO) and sludge production, and associated WAS flow rate and solids retention time (SRT). Observed average temperatures were used in model.
- The DO concentration in basins where diffusers and surface aerators are installed was set to the average DO concentration maintained during winter and summer months.
- The modeled WAS flow rates were set to the average WAS flow rates measured during the winter months and summer months.
- Typically, oxidation ditches exhibit a degree of denitrification due to the creation of small anoxic zones within the reactor. To model simultaneous Nitrification/Denitrification (SNDN) in BioWin 6.2, the *OHO DO half sat.* switch is adjusted from the default of 0.15 to 0.20, which allows more anoxic activity to occur in the presence of oxygen. This modification is necessary to reflect the observed occurrence of denitrification as indicated by the effluent nitrate concentrations.

- The OWRF laboratory measured an average of 6.92 mg/L of nitrate in the facility's influent. This value is unusually high since most sewers experience mostly anaerobic conditions. The presence of nitrate in raw sewage may occur due to nitrate addition in the upstream sewer for odor control or due to industrial discharges. The presence of nitrate in the facility influent affects the removal of TSS and BOD in primary clarifiers. Primary clarifiers are generally anaerobic in nature, and if nitrates are present some denitrification may be observed, resulting in nitrogen off-gassing that may hinder settling. The OWRF primary clarifiers are exhibiting excellent BOD removal, so it is unlikely that off-gassing is occurring. Nitrate loads in influent wastewater may also poison bioreactor anaerobic zones, resulting in a higher carbon demand for denitrification and reduced biological phosphorous removal efficiency. The nitrate measured in the facility's influent is neglected in the model calibration, analysis of primary clarifier performance, and effluent TP. However, if OWRF staff continue to measure high nitrate concentrations in the influent using certified laboratory test results, then the *OHO DO half sat.* switch mentioned above will need to be adjusted to its maximum suggested value of 0.40 for calibration.
- A high ratio (greater than 80%) of mixed liquor volatile suspended solids (MLVSS) to mixed liquor suspended solids (MLSS) was observed. A high volatile solids (VS) concentration indicates the presence of a smaller inert fraction. Thus, the model stoichiometric parameter 'Particulate inert COD: VSS ratio (mg COD/mg VSS)' was reduced to 0.9 from its default value of 1.6 to reflect the high MLVSS concentrations observed at the OWRF. This model ratio correlates with the COD fractionation study conducted for the Provo City Water Reclamation Facility (PCWRF). The ratio of MLVSS:MLSS at PCWRF is approximately 80%, resulting in the adjustment of the 'Particulate inert COD: VSS ratio (mg COD/mg VSS)' being adjusted to 1.0 in the modeling for that facility. Considering the similarity in location and constituents of the Orem City and Provo City service areas, a similar stoichiometric parameter value is justified.
- 65% removal of inorganic suspended solids (inert solids) was modelled for the grit basins to help reflect the high MLVSS measurements at the bioreactors.
- *Digester Improvements Workshop Technical Memorandum No. 2* submitted by Carollo Engineers in July 2016 indicates that primary sludge total solids concentrations results from the OWRF laboratory were higher than the results from the limited certified laboratory data provided. The OWRF laboratory measured 1.5% to 2.5% primary sludge solids concentrations whereas the certified laboratory measured 1% to 1.5% primary sludge solids concentrations. The use of a 1% solids value resulted in a better correlation between the modeled and observed facility performance, so this value will be used in the process analysis.
- Equal primary influent and RAS flow splits were assumed between the bioreactors.
- RAS flow rates are currently not tracked in the plant data. Setting the model RAS flow rate to 1Q (RAS flow equal to 1x the influent flow) results in the modeled performance closely correlating with the SRT and MLSS concentrations observed at the OWRF.
- The mixed liquor recirculation pumps located in BNR3, which are used to pump mixed liquor to the anoxic basins have a total capacity of 9 mgd. OWRF staff indicated that 75% of the pumping

systems total capacity is being used. The recirculation flow rate is adjusted in the model to reflect these operating conditions.

- Typically, horizontal flow velocity in oxidation ditches is designed for 0.5 to 1.0 ft/s. The design horizontal flow velocity in the bioreactors is not recorded. Setting the horizontal flow velocity to approximately 0.35 ft/s results in the best correlation between the model predicted performance and the operational data. Although this is lower than typical design values, it is used in the model analysis.
- The solids concentration of the thickened WAS and combined primary sludge in the digester feed is approximately 2%. This value is utilized in the model.
- Biowin 6.2 does not include reactors to represent thermophilic digester process units and does not allow digester temperatures above 40°C. EnviroSim representatives indicated that the specifics concerning specialist organisms and other factors in thermophilic digesters are not fully known. To allow the model account for thermophilic digesters, EnviroSim suggested increasing the anaerobic digester's hydrolysis factor, endogenous products decay rate, and anaerobic decay rate to model thermophilic digester performance. They also suggested increasing the Arrhenius factor to account for the higher temperature of the thermophilic digester for all parameters indicated above. Table 2 summarizes the changes made to the thermophilic digester parameters in the model.

Table 2 Thermophilic Digester Model Kinetic Parameters

Parameter	Biowin 6.2 Default Value	Value Used
Anaerobic digester hydrolysis factor	0.5	0.75
Endogenous products decay rate (1/day)	0	0.0075
Anaerobic decay rate (1/day)	0.1310	0.17
Arrhenius factor for Anaerobic digester hydrolysis factor	1	Winter Month: 1.1 Summer Month: 1.2
Arrhenius factor for endogenous products decay rate	1	Winter Month: 1.1 Summer Month: 1.2
Arrhenius factor for anaerobic decay rate	1.029	Winter Month: 1.1 Summer Month: 1.2

- The OWRF's aerobic digester is primarily used as a sludge holding tank. Hence, the aerobic digester is not modeled as part of the OWRF treatment process. This will prevent inadvertently predicting phosphorous removal or other biological activity in the aerobic digester that is not actually occurring.
- The concentration of thickened solids leaving the belt filter press is assumed to be approximately 16% based on operational data.
- The alum concentration was unknown and dosing rates at different locations were based on estimates. OWRF used 324 tons of aluminum sulfate in 2020 based on communication with the Utah DWQ on January 26, 2021. Assuming an alum concentration of approximately 48%, the

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alum dose associated with this usage is approximately 500 gal/day. Table 3 summarizes the estimated alum dose at the facility's known feed locations. Changing the total aluminum sulfate dose rate within the facility will affect the model's predicted performance, but changing the relative dose at the feed locations while maintaining the overall dose will have less impact on the predicted performance.

Table 3 Assumed Aluminum Dose at Facility Feed Locations

Dosing location	Winter Month Model (gal/day)	Summer Month Model (gal/day)
Headworks	50	100
Before Belt Filter Press	250	350
Filtrate	50	50
Total	350	500

2.4 Winter and Summer Month Calibrated Model

Table 4 and Table 5 present the results of the calibrated model in comparison with the facility's performance data. The percent difference column is included as a performance indicator. Although it is not possible for the model to predict all performance parameter exactly for all model runs, a percent difference in the 0 – 10% range is considered acceptable, but less than 5% is preferred.

The predicted performance using the calibrated model is in agreement with the actual OWRF performance observed in the 2020 winter and summer months. The % difference for most of the parameters is less than 10%. The MLSS, MLVSS, SRT of the bioreactors, and the solids stream process performance are within 10% of observed performance.

The predicted primary effluent total phosphorous is lower than the measured value from the OWRF laboratory. This is likely due to the OWRF laboratory's tendency for providing total phosphorus results that are higher than the actual values as discussed previously.

The model predicts a lower yield compared to the yield calculated based on HACH WIMS data, but the MLSS, MLVSS, SRT of the bioreactors track closely to the plant performance.

Although the percent difference values for the predicted and measured values for effluent ammonia and nitrite are high, these concentrations are very low, so a minor difference of less than 0.5 mg/L results in a high percent difference. The ammonia value predicted by the model is less than 0.5 mg/L and the measured values are also less than 0.5 mg/L. Similarly, model nitrite values are less than 0.2 mg/L and plant measured values are less than 0.2 mg/L.

Based on the above comparisons the model provides a reasonable representation of how the facility is currently operating and can be used for the further analysis of process optimization and improvement.

Table 4 Comparison of Winter (January to March) Calibrated Model

Parameter	OWRF Observed Value (Average)	Calibrated Model Value	% Difference
Influent			

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Parameter	OWRF Observed Value (Average)	Calibrated Model Value	% Difference
Flow (mgd)	8.95	8.95	0%
BOD (mg/L)	255	255	0%
TSS (mg/L)	231	231	0%
VSS (mg/L)	Not Measured	196	-
TKN (mg/L)	Not Measured	45	-
NH ₃ -N (mg/L)	36	36	0%
TP (mg/L)	6.4	6.4	0%
pH	Not Measured	7.5	-
Temperature (°C)	14.0	14.0	0%
Primary Clarifier			
BOD removal (%)	30	29	5%
TSS removal (%)	Not Measured	59	-
Primary Effluent TP ¹ (mg/L)	5.4	4.3	20%
Bioreactor			
MLSS (mg/L)	2518	2615	-4%
MLVSS (mg/L)	2185	2180	0%
MLVSS/MLSS (%)	86	83	4%
SRT (days)	20	21	-4%
Yield ² (lbs of WAS TSS/lbs of Influent BOD)	0.49	0.37	25%
WAS			
WAS Flow (mgd)	0.17	0.16	6%
WAS MLSS ³ (mg/L)	5273	5221	1%
WAS MLVSS ³ (mg/L)	4534	4354	4%
Thermophilic Digester			
Volatile Solids Reduction ⁴ (%)	53.7	51.3	4%
Gas Flow Rate (%)	81.1	80.4	1%
pH	7.3	6.9	6%
Mesophilic Digester			
Volatile Solids Reduction ⁴ (%)	8.2	7.2	13%
pH	7.1	7.0	2%
Effluent			
BOD (mg/L)	<5	2.3	-
TSS (mg/L)	5.7	5.2	8%
NH ₃ -N (mg/L)	0.28	0.36	-29%
NO ₃ -N (mg/L)	8.3	8.3	0%
NO ₂ -N (mg/L)	0.05	0.16	-220%

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Parameter	OWRF Observed Value (Average)	Calibrated Model Value	% Difference
TP (mg/L)	2.4	2.4	-1%
pH	7.2	7.6	-6%
Notes: 1. The difference in values is likely the result of the over representation of TP concentration in samples measured at the OWRF laboratory. 2. Typically, yield is measured using a ratio of lbs of VSS in WAS to lbs of bioreactor influent BOD, but the HACH WIMS data uses lbs of TSS wasted (not VSS). The OWRF influent flow and BOD measurements are more reliable than the bioreactor influent flow and BOD. To address this, yield was calculated as the ratio of lbs of WAS TSS/lbs of influent BOD. 3. WAS MLSS and MLVSS is not measured. However, RAS MLSS and MLVSS is measured. It is assumed that MLSS and MLVSS in the WAS and RAS are the same. Value presented is the MLSS and MLVSS measured for the RAS. 4. OWRF measures volatile solids reduction by the Van Kleeck Method.			

Table 5 Comparison of Summer (July to September) Calibrated Model

Parameter	OWRF Observed Value (Average)	Calibrated Model Value	% Difference
Influent			
Flow (mgd)	9.00	9.00	0%
BOD (mg/L)	212	212	0%
TSS (mg/L)	231	231	0%
VSS (mg/L)	Not Measured	196	-
TKN (mg/L)	Not Measured	42.6	-
NH ₃ -N (mg/L)	34.1	34.1	0%
TP (mg/L)	5.9	5.9	0%
pH	Not Measured	7.5	-
Temperature (°C)	22.4	22.4	0%
Primary Clarifier			
BOD removal (%)	39.1	37.7	4%
TSS removal (%)	Not Measured	59.5	-
Primary Effluent TP ¹ (mg/L)	4.5	3.8	15%
Bioreactor			
MLSS (mg/L)	1994	2105	-6%
MLVSS (mg/L)	1594	1700	-7%
MLVSS/MLSS (%)	80.9	80.7	0%
SRT (days)	24.0	23.3	3%
Yield ² (lbs of WAS TSS/lbs of Influent BOD)	0.36	0.31	14%
WAS			
WAS Flow (mgd)	0.14	0.14	0%
WAS MLSS ³ (mg/L)	4574	4202	8%

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Parameter	OWRF Observed Value (Average)	Calibrated Model Value	% Difference
WAS MLVSS ³ (mg/L)	3664	3393	7%
Thermophilic Digester			
Volatile Solids Reduction ⁴ (%)	63.0 ⁵	61.3	3%
Gas Flow Rate (%)	74.6	71.0	5%
pH	7.2	6.8	6%
Mesophilic Digester			
Volatile Solids Reduction ⁴ (%)	6.0 ⁵	4.1	32%
pH	7.1	6.9	3%
Effluent			
BOD (mg/L)	<5	1.9	-
TSS (mg/L)	5.6	5.1	9%
NH ₃ -N (mg/L)	0.13	0.17	-31%
NO ₃ -N (mg/L)	10.1	10.3	-1%
NO ₂ -N (mg/L)	0.06	0.11	-83%
TP (mg/L)	2.1	2.3	-10%
pH	7.3	7.7	-5%
Notes: 1. The difference in values is likely the result of the over representation of TP concentration in samples measured at the OWRF laboratory. 2. Typically, yield is measured using a ratio of lbs of VSS in WAS to lbs of bioreactor influent BOD, but the HACH WIMS data uses lbs of TSS wasted (not VSS). The OWRF influent flow and BOD measurements are more reliable than the bioreactor influent flow and BOD. To address this, yield was calculated as the ratio of lbs of WAS TSS/lbs of influent BOD. 3. WAS MLSS and MLVSS is not measured. However, RAS MLSS and MLVSS is measured. It is assumed that MLSS and MLVSS in the WAS and RAS are the same. Value presented is the MLSS and MLVSS measured for the RAS. 4. OWRF measures volatile solids reduction by the Van Kleeck Method. 5. Volatile solids reduction measurements in August 2020 were different than average observed values for other months. VSR measurements for August were consider nonrepresentative and measurements from July and September are considered.			

3. Capacity of the Treatment Process at Average Day Maximum Month (ADMM) Load and Design flow

The process model includes all three bioreactors, all four primary clarifiers, all four secondary clarifiers, and all of the digesters. As indicated in the *Flows and Loads Technical Memorandum*, the design loads presented in the facility design documents includes higher BOD and TSS concentrations than what the facility is experiencing. This results in more carbon being available for phosphorus removal and denitrification, resulting in predicted performance being better than actual current facility performance. The ADMM load conditions recommended in this report provide a more conservative load condition than the OWRF will likely experience.

The treatment capacity predicted by the model was checked at a design flow of 13.5 mgd using ADMM load concentrations as described in the *Flows and Loads Technical Memorandum*.

Table 6 summarizes the predicted performance of the treatment process for winter and summer temperature conditions. The model was run using current OWRF operational strategies: a similar SRT, primary sludge thickening (1% to 1.5%), WAS thickening (2% to 2.2%), RAS flow rate, etc. However, the high DO setpoints currently reported were not used. The DO setpoints were set based on blower and surface aerator capacity. The alum dose was increased proportionally to the influent flow rate.

Using these conditions, the model predicted that the thermophilic digester will not achieve its minimum design SRT of 6 days, and the mesophilic digesters will not achieve their design SRT of 8 days due to higher hydraulic loading of the digesters. As a result, the model predicts that partial digestion will occur and that the acidogenesis process will dominate. The model predicts that the digesters will become more acidic (also known as sour digester) and that methane formation will be reduced. Therefore, the model predicts that carbon that would normally be converted to methane will be returned to the liquid stream process in the dewatered sludge filtrate. The additional carbon from this sidestream flow will improve biological phosphorous and nitrogen removal. This is shown in the effluent summarized below in Table 6. However, the acidic digestion process is not stable and has the potential to generate significant odors. In addition, production of class A biosolids may not be achievable.

Table 6 Predicted Treatment Process Performance at Design Flow and ADMM Load

Parameter	Model Value	
Influent Flow (mgd)	13.5	
Influent BOD (mg/L)	261	
Influent TSS (mg/L)	276	
Influent TKN (mg/L)	50.80	
Influent NH ₃ -N (mg/L)	40.6	
Influent TP (mg/L)	6.8	
Influent pH	7.5	
	Winter Month Model	Summer Month Model
Temperature (°C)	13.5	23.1
Bioreactor SRT (days)	18.6	21.7
Bioreactor Average MLSS (mg/L)	3628.	3935.
RAS Flow Rate (mgd)	13.2	13.3
WAS Flow Rate (mgd)	0.26	0.22
Thermophilic Digester SRT (days)	3.9	4.0
Mesophilic Digester SRT (days)	5.4	5.6
Aluminum Sulfate Dose (gal/day)	550	750
Belt Filter Press Filtrate TP (mg/L)	39.4	20.4
Effluent BOD (mg/L)	3.6	3.6
Effluent TSS (mg/L)	7.3	7.9
Effluent NH ₃ -N (mg/L)	2.1	0.64

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Effluent TIN (mg/L)	3.9	1.2
Effluent TP (mg/L)	0.41	0.46

Based on the digester model observations discussed above, primary sludge and WAS are thickened to a combined sludge solids concentration of 3% to improve digester SRTs. Sludge thickening improvements (such as Primary/WAS sludge co-thickening improvements) will be discussed further in the *Management of Biosolids Technical Memorandum*. Sludge thickening to 3% solids allows the digestion process to achieve design SRTs at the design flow and ADMM load. Table 7 summarizes results from the model that reflect improved sludge thickening. Sludge thickening allows the modelled digesters to achieve design SRTs. Modeled volatile solids reduction and methane formation was similar to currently observed OWRP performance values. The model results indicate that the facility will meet effluent ammonia, BOD, and TSS requirements, but an effluent TP of less than 1 mg/L and TIN of less than 10 mg/L will not be achievable employing current facility operations practices.

Table 7 Predicted Process Performance at Design Flow and ADMM Load with Biosolids Thickening

Parameter	Model Value	
Influent Flow (mgd)	13.5	
Influent BOD (mg/L)	261	
Influent TSS (mg/L)	276	
Influent TKN (mg/L)	50.8	
Influent NH ₃ -N (mg/L)	40.6	
Influent TP (mg/L)	6.8	
Influent pH	7.5	
	Winter Month Model	Summer Month Model
Temperature (°C)	13.5	23.1
SRT (days)	17.4	17.4
Bioreactor Average MLSS (mg/L)	2289	2328
RAS Flow Rate (mgd)	9.9	9.9
WAS Flow Rate (mgd)	0.24	0.24
Thermophilic Digester SRT (days)	9.1	9.1
Mesophilic Digester SRT (days)	12.6	12.6
Aluminum Sulfate Dose (gal/day)	600	750
Belt Filter Press Filtrate TP (mg/L)	88.5	85.7
Effluent BOD (mg/L)	2.1	2.1
Effluent TSS (mg/L)	4.0	4.1
Effluent NH ₃ -N (mg/L)	0.73	0.44
Effluent TIN (mg/L)	10.6	3.81
Effluent TP (mg/L)	2.4	1.5

Based on the discussion above, further analysis of process optimization and improvement alternatives is conducted assuming that the primary sludge and WAS will be thickened to 3%. Implementing solids

thickening to achieve 3% solids feed into the digesters will enable the OWRF to produce Class A or Class B biosolids and meet stringent conditions for TP and TIN removal.

4. Existing Treatment Process Optimization and Improvement

Based on the results of the model analysis the following process optimization and improvement options were identified:

- Ammonia Based Aeration Control (ABAC)
- RAS Flow control
- Modification of the Alum Dosing Location

4.1 Ammonia Based Aeration Control (ABAC)

Currently, the treatment process is maintaining a relatively high DO of 2 to 4 mg/L in its bioreactors and achieving effluent ammonia less than 1 mg/L at all times. This indicates that the OWRF is achieving complete nitrification resulting in high concentrations of nitrate in the effluent and the RAS. When nitrified RAS containing high amounts of nitrate is returned back to the anaerobic basin, denitrification is the primary biological process that will occur. In addition, if DO levels in the bioreactor are very high, the DO entrained in the RAS enters the anaerobic basins as well. This is evident in the calibrated model results, which show oxygen uptake in the first anaerobic basin of each bioreactor. In support of the model results, the presence of DO and nitrate was observed in sampling conducted by Carollo Engineers in the anaerobic zones. The models show that the first anaerobic zone of the OWRF is operating as a deoxygenation zone and anoxic basin where DO and nitrate are removed. Thus, the effective anaerobic basin volume is reduced carbon critical to effective biological phosphorus removal is consumed. In biological nutrient removal processes, denitrifying bacteria compete with phosphorous accumulating organisms (PAOs) for carbon. Reduced carbon in the anaerobic zones reduces the efficiency of the PAOs in the biological phosphorus removal process. Sufficient anaerobic volume and sufficient carbon concentrations are both critical factors in the facility's phosphorus removal performance. The return of DO and nitrate to the anaerobic zone are currently inhibiting this process.

OWRF's current UPDES permit allows effluent ammonia concentrations to be as high as 3 mg/L in the Summer months and as high as 5 mg/L in the Winter months. Controlling DO and nitrification in the bioreactors to meet, but not exceed, effluent requirements will limit the amount of DO and nitrate returned to the anaerobic zone of the bioreactors with the RAS. This will improve the phosphorus removal capability of the bioreactors by reducing the amount of volume lost within the anaerobic zone to complete deoxygenation and denitrification. In addition, reducing the concentration of nitrate requiring denitrification will increase the amount of carbon available for phosphorus removal.

The calibrated winter model was run with a low DO setpoint within the bioreactors to achieve an effluent ammonia concentration less than 5 mg/L while maintaining the same SRT. Table 8 summarizes the result of this analysis. The results indicate that decreasing the DO setpoint to reduced nitrification within the bioreactors reduced the nitrite and nitrate concentration in the RAS from 8.47 to 1.6 mg/L. In addition, the RAS DO concentration is reduced from 2.47 mg/L to 0.21 mg/L, resulting in reduced oxygen uptake demand in the first anaerobic basin from 3.3 to 0.28 mg of Oxygen/L/hr. The effectiveness of controlling for a reduced DO can be observed in the predicted effluent results

presented in Table 8. TP is reduced from 2.5 mg/L to 1.4 mg/L while achieving effluent ammonia concentrations less than 5 mg/L for the Winter months.

Table 8 Performance of Calibrated Winter (January to March) model With and Without ABAC

Parameter	Value	
Temperature	14.0	
Influent Flow (mgd)	9.0	
Influent BOD (mg/L)	254	
Influent TSS (mg/L)	230	
Influent TKN (mg/L)	45.4	
Influent NH ₃ -N (mg/L)	36.3	
Influent TP (mg/L)	6.4	
	Calibrated Winter Model	Calibrated Winter Model with ABAC
SRT (days)	20.8	20.8
Bioreactor Average MLSS (mg/L)	2615	3093
RAS Flow Rate (mgd)	9.0	9.0
WAS Flow Rate (mgd)	0.16	0.16
DO in RAS (mg/L)	2.5	0.21
Nitrate in RAS (mg/L)	8.3	0.00
Nitrite in RAS (mg/L)	0.15	1.6
Oxygen uptake rate (OUR) in first Anaerobic Zone (mg of Oxygen/L/ hr)	3.3	0.28
Total Aluminum Sulfate dose (gal/day)	350	350
Effluent BOD (mg/L)	2.3	3.3
Effluent TSS (mg/L)	5.2	6.2
Effluent NH ₃ -N (mg/L)	0.36	3.2
Effluent TIN (mg/L)	8.8	4.8
Effluent TP (mg/L)	2.5	1.4

For ABAC, the DO setpoints are dependent on the mixed liquor ammonia concentration, allowing for the aeration demand to match the DO requirements for nitrification. Figure 2 shows a schematic of a typical ABAC process. An ammonia analyzer measures the ammonia in the target location. The measured value is compared to an ammonia setpoint. The aeration system airflow is varied as necessary to achieve the aeration demand required to achieve the required ammonia concentration setpoint.

Depending on the DO setpoint required to achieve the target ammonia concentration, the system can be operated to further reduce the nitrate concentration through promotion of simultaneous Nitrification Denitrification (SNDN) which is often observed in oxidation ditches. Minimizing the DO within the bioreactors will result in zones within the basins that reach an anoxic condition, resulting in denitrification. The ABAC process improvement will allow the basins to be operated at lower DO

concentrations resulting in improved phosphorus and nitrogen removal while maintaining effluent ammonia concentrations below the permitted limit. This process has been successfully implemented in full scale process trains with proven performance improvements.

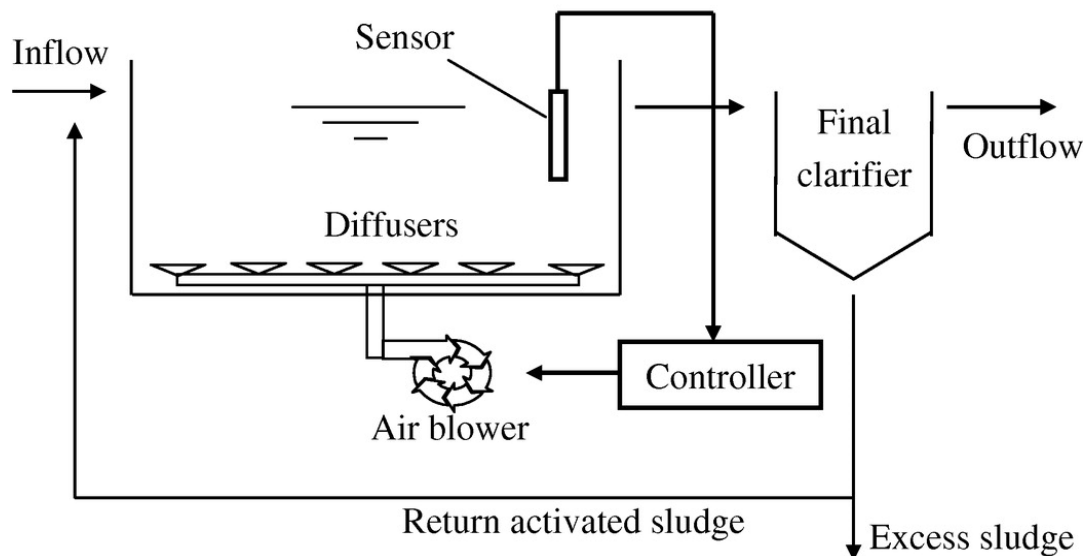


Figure 2 Typical ABAC Process Schematic

For successful implementation of ABAC, ammonia measurement in the mixed liquor is required. Two types of ammonia analyzers are commonly available, ammonium ion selection electrode (ISE) analyzers and ammonia wet chemistry analyzers. ISE analyzers consist of a probe that is submerged in the process water and a controller. They are lower in capital cost than wet chemistry units but do not provide stable and repeatable measurements at ammonia concentrations less than 1 mg/L, which may be encountered in ABAC based process control if the facility's ammonia limit is lower than 2.0 mg/L. In addition, the ISE analyzers' ammonium probe cartridge life is relatively short, requiring replacement as often as annually. ISE analyzers also require frequent calibration, which is the main operation and maintenance requirement for these units. Wet chemistry systems include systems for drawing and conditioning a sample, chemical addition, sample analysis and sample/chemical disposal. They provide more stable, accurate, and repeatable measurements at ammonia concentrations less than 1.0 mg/L. These systems are also capable of automatically recalibrating, resulting in more reliable results. Wet chemistry analyzers are more complex, requiring maintenance of sampling and sample disposal systems, and include the use of chemicals that need to be provided and monitored. These chemicals must also be disposed of resulting in increased operation and maintenance. The selection of the appropriate analyzers is critical in the implementation ABAC. It is expected that the target ammonia concentration leaving the bioreactors, based on the OWRF discharge requirements, will be above 1.0 mg/L, so it is anticipated that ISE analyzers will be suitable.

Other process changes required for implementation of ABAC include changes to the aeration control strategy and the associated modification of the PLC programming. This work is minimal, resulting in a relatively low capital investment. If implemented, ABAC will result in the OWRF discharging a higher

ammonia load than it currently does. In the future, if stricter effluent ammonia discharge requirements are imposed on the facility, the ABAC process will not be an effective solution.

OWRF's BNR3 was constructed with improved aeration control capabilities. If ABAC is identified as a preferred option for process improvements, it is recommended that ABAC be piloted in BNR3 to determine if it can be implemented with acceptable effort and achieve acceptable results.

4.2 RAS Flow Control

Currently, the OWRF does not have reliable RAS flow measurement or effective control over RAS flow. This lack of control on the RAS system is expected to create challenges in the efficient operation of the bioreactors. To identify the impacts of these challenges, the calibrated model was run with uneven RAS flow splits between the bioreactors. The results of this analysis indicated that moderately uneven RAS flow did not change the overall treatment process performance to a considerable extent. Minor changes to the MLSS concentration, SRT, nitrification & denitrification performance, and phosphorous removal performance were observed. However, as the difference in RAS flow between the bioreactors was increased, more significant process inhibition was observed, including reduced nitrification resulting in higher effluent ammonia and increased aeration requirements for the more heavily loaded bioreactor. Analysis of the current operational data indicates that the MLSS concentration in the two operating bioreactors is similar, suggesting that the RAS is being distributed relatively evenly between the bioreactors. Lack of RAS flow split control does not appear to be a significant issue for the facility.

Operation of the facility without knowing the RAS flow rate and with only manual control of the flow rate is an operational challenge. The RAS flow rate is used to control the SRT of the treatment process. Currently when the SRT needs to be adjusted, the OWRF operators manually adjust the RAS control valves, but have little feedback on the impact of these adjustment on the RAS flow. For effective and stable nutrient removal performance, including ABAC if implemented, requires effective SRT control. It is recommended that modifications be made to the OWRF to provide automated and accurate RAS flow measurement and control.

4.3 Aluminum Sulfate Dosing location

The OWRF utilizes alum feed for phosphorus removal. Operators have the ability to feed alum to the headworks, and to the belt filter press solids feed and filtrate. Currently facility operators feed alum continually at the headworks and the belt filter press feed. Alum is occasionally fed to the belt filter press filtrate. Varied alum feed rates were modeled at these locations to determine the optimal feed locations and feed rates to maximize the effectiveness of the phosphorus removal system. The results of this analysis indicate that alum feed is most effective at the belt filter press feed. In this location, the flowrate is 0.1 to 0.2 mgd with relatively high orthophosphate concentrations in the range of 100 to 250 mg/L. In comparison, flow at the headworks ranges from 8 to 20 mgd and orthophosphate concentrations range from 4 to 7 mg/L. Alum feed at the belt filter press feed will support increased reaction kinetics due to the higher concentration of orthophosphate, resulting in lower chemical demand.

5. Treatment Process Options

The existing OWRF treatment process was analyzed using the calibrated process model at design flows and ADMM loading conditions to identify the facility's limitations in meeting current and future treatment objectives. This analysis identified carbon limitation in the liquid stream process and high nutrient loads in the return flows from the dewatering process as key factors that currently inhibit the facility's performance.

5.1 Carbon Limitation

Within the bioreactors, the organisms that perform denitrification compete with the organisms that perform phosphorus removal (PAOs) for the available carbon. Although the OWRF discharge permit does not require denitrification for nitrogen removal, denitrification does occur within the anaerobic and anoxic zones of the bioreactors whenever nitrate and nitrite are present. Additionally, denitrification is performed preferentially to phosphorus removal, resulting in much of the carbon necessary to complete phosphorus removal being utilized by denitrifying organisms. As discussed in the *Flows and Loads Technical Memorandum*, the OWRF secondary treatment process is carbon limited for biological phosphorous removal and denitrification, based on a stoichiometric analysis. Process analysis using the calibrated process model supported this conclusion since adequate phosphorus removal was not observed without the addition of a carbon source. To improve biological phosphorous removal efficiency, treatment alternatives that will supplement carbon to mainstream treatment processes, or limit the carbon demand for denitrification, should be considered to address the carbon limitations preventing the facility from meeting its currently permitted phosphorus limits.

5.2 Treatment Alternatives to Address Carbon Limitation

WaterWorks screened several options for providing supplemental carbon to the bioreactors. The options expected to be most suitable for the OWRF are chemical carbon addition, primary influent bypass and primary solids fermentation. The evaluation of these options is discussed in the following sections.

5.2.1 Chemical Carbon Addition

Chemical carbon sources such as acetate may be fed to the anaerobic basins to improve biological phosphorous removal. Similarly, chemical carbon sources such as methanol, ethanol, candy carbon, or Micro C may be introduced in the anoxic basin for improving denitrification and achieving lower effluent nitrogen. Chemical addition will require capital investments to provide storage and feed facilities and will result in increased operational costs for chemical purchases. In addition, storage and handling of chemicals, especially ethanol, which is flammable and hazardous, requires special considerations to maintain operator safety. For these reasons, chemical carbon addition is not a preferred option and will be considered if all other options are found to be inadequate.

5.2.2 Primary Bypass

Influent raw wastewater contains a considerable amount of carbon in the form of volatile fatty acids such as acetic acid, propionic acid and biodegradable organic carbon that are a preferred carbon sources for PAOs and denitrifying bacteria. Currently, the primary clarifiers are exhibiting excellent

BOD and TSS removal (30% to 40% removal), which results in the removal of much of the carbon that is needed in the secondary process. Bypassing a portion of the primary influent flow to the bioreactors will supplement the carbon available within the bioreactors to support efficient phosphorus removal and denitrification.

This approach was analyzed using the calibrated process model. The results of this analysis indicate that bypassing 20% to 40% of the primary influent to the bioreactors provides sufficient carbon to the treatment process, reducing effluent TP to less than 1.0 mg/L and TIN to less than 10.0 mg/L.

Primary bypass will result in grit being introduced into the bioreactors if the grit removal process is not performing efficiently. The increased BOD and TSS loading on the bioreactors will increase the MLSS and MLVSS by up to 20% in the bioreactors, requiring increased mixing and aeration. In addition, the increased MLSS will increase the solids loading rate on the secondary clarifiers. The anticipated loading based on the results of the process analysis is within the design solids loading rate for the clarifiers. Further analysis of the clarifiers using state point analysis may be conducted to confirm that the clarifier performance will be acceptable. Impacts of the increased MLSS on the solids processing system is discussed in the *Management of Biosolids Technical Memorandum*.

The existing mechanical design of the OWRF includes the ability to bypass primary influent to the bioreactors. However, the system does not have an effective mechanism for flow control and measurement. Minor modifications to the existing infrastructure will be required to bypass and control primary bypass flows.

5.2.3 Primary Sludge Fermentation

In primary sludge fermentation, settled solids from primary clarifiers are thickened and fermented. The reactor is designed to provide sufficient SRT to promote hydrolysis of long chain molecules to create short chain VFAs. The supernatant from the fermenter, which is rich in volatile fatty acids and biodegradable carbon, is fed to the bioreactors where it is utilized by PAOs and denitrifying bacteria to perform biological phosphorous removal and denitrification. One of the main advantages of primary sludge fermentation is that it generates volatile fatty acids, increasing their concentration in the bioreactor influent. This is helpful if the influent contains low concentration of fatty acids and the anaerobic volume is not sufficient to complete hydrolysis of biodegradable carbon to generate fatty acids. Primary sludge fermentation has been successfully implemented at many full-scale plants to improve biological phosphorous and nitrogen removal. There are many different configurations of primary sludge fermenter such as complete-mix fermenters, single-stage fermenter/thickeners, two stage complete-mix fermenter/thickeners, and unified fermentation and thickening. For the OWRF treatment process, a single stage fermenter/thickener as shown in Figure 3 is suggested.

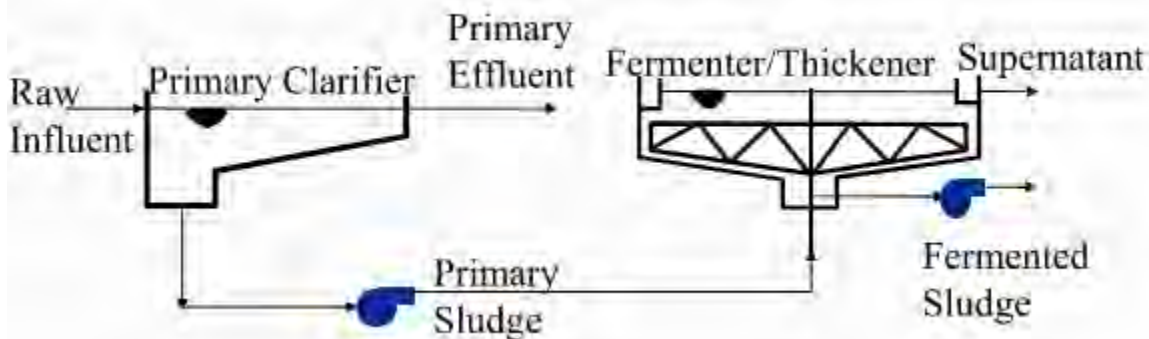


Figure 3 Single Stage Primary Sludge Fermenter/Thickener Schematics

The calibrated model was modified to include a primary sludge fermenter with minimum SRT of 3 days as suggested by published articles. Modeling indicated that 2000 to 3500 mg/L volatile fatty acids will be generated to provide supplemental carbon within the bioreactors. The model results showed improved biological phosphorous removal resulting in effluent TP less than 1 mg/L. This model also predicted a TIN concentration of less than 7.5 mg/L for summer conditions. However, model runs for winter temperatures were not able to reduce TIN concentration to less than 10 mg/L. Further modifying the model to increase the size of the primary sludge fermenter to provide 5 days or more SRT, generating 6000 to 7000 mg/L of volatile fatty acids, resulted in an effluent TIN of less than 10 mg/L and a TP less than 1.0 mg/L. Since the OWRF's current UPDES permit requires effluent TP of less than 1.0 mg/L, a smaller primary sludge fermenter with 3 days SRT is suggested. In the future, if TIN limits are imposed, the primary sludge fermenter capacity can be increased, or If the future TIN limit is based on an average annual load similar to the TP limit, an annual average of less than 10 mg/L may be achievable.

A primary sludge fermenter/thickener will thicken the primary solids, reducing the load on the anaerobic digesters and solids processing systems, which may improve the performance of these systems. The impact of the reduced loading to the digesters is discussed further in the *Management of Biosolids Technical Memorandum*. The fermentation process will create odors. Odor control measures to contain and control the odors will be discussed in the *Odor Treatment Technical Memorandum*.

The implementation of this option will require significant capital expenditures to construct the required reactor and associated mechanical mixing and pumping systems. Thickening and fermentation of settled primary sludge within existing primary clarifiers may be considered to reduce the capital cost. If this option proves to be preferred, a thorough evaluation of the existing primary clarifier performance will be required.

5.3 Side stream Phosphorous Removal

Phosphorous removed from the main liquid stream process is accumulated in the biosolids. When the biosolids are placed in anaerobic conditions within the digesters, phosphorus release occurs. This currently results in the phosphorus being returned to the liquid stream within the filtrate created during dewatering. This makes biological phosphorous removal treatment ineffective because the phosphorous removed during secondary treatment is returned back to the system. Currently OWRF is

adding alum before and after the belt filter press to reduce the phosphorous load in the side stream. Alternative treatment options are available for consideration to reduce chemical costs and improve phosphorus removal performance. These options are discussed in the following sections.

5.3.1 Post Aerobic Digestion (PAD)

In post aerobic digestion, anaerobically digested sludge is intermittently aerated creating alternating aerobic and anaerobic/anoxic environments. Under aerobic conditions, nitrification occurs, and PAOs within the sludge will take up phosphorus. During the anaerobic/anoxic phase, the sludge is mixed but not aerated. Under these conditions denitrification occurs and the PAOs are conditioned for enhanced phosphorus uptake. Additionally, aeration promotes the release of carbon dioxide (CO₂) from the anaerobically digested sludge resulting in increased pH. If the pH can be induced to rise above 7.5 to 8.5 struvite stabilization will occur within the reactor resulting in the formation of struvite crystals that are removed with the solids during dewatering. This results in the removal of phosphorus as well as the prevention of struvite scaling within the solids piping and/or dewatering equipment. The PAD process has the potential to reduce the ammonia and phosphorous loads in the sidestream filtrate, which can greatly improve the performance of the secondary treatment system. The PAD process may also result in additional volatile solids reduction.

The PAD process also destroys exocellular polymeric substances (EPS), which bind water within the biosolids structure making dewatering more difficult. Due to this, the PAD process improves the dewaterability of digested sludge resulting in higher solids content in the dewatered cake, and/or reduction in the required usage of chemical and polymer for solids dewatering. Additionally, the PAD process reduces biosolids odor due to aeration.

Although the PAD process offers many potential benefits, it also requires significant attention in its operation and control. PAD processes often require alkalinity addition to promote nitrification. In addition, the PAD process is exothermic producing significant heat. Current research indicates that a cooling system may be required during Summer months to maintain acceptable performance.

The existing OWRF treatment process includes aerobic digesters that are currently being used as solids holding and equalization tanks. New blowers are being procured to equip the aerobic digesters to maintain mixing. The treatment process model was modified to include a PAD process in the sidestream design. It was observed that a PAD process results in the removal of ammonia and phosphorous from the sidestream if the PAD reactor is supplemented with carbon from the primary processes. Unfortunately, preliminary modeling results indicate that 60% to 80% of the primary sludge will need to be diverted to the PAD reactors to support their operation. In addition, the PAD reactors may experience calcium and magnesium limitations. Class A biosolids will not be achievable if this amount of primary solids is diverted to the anaerobic digesters due to reduced pathogen destruction. The process model indicates that PAD may result in 10% to 20% additional volatile solids reduction. If primary sludge is not diverted to the aerobic digesters, they can still be used for ammonia, nitrite and nitrate reduction by intermittent aeration. This will reduce the sidestream nitrogen load on the mainstream process and make more carbon available for phosphorous removal. The process model indicates that aerobic digesters without primary sludge feed will reduce the ammonia load by 50% to 60% and phosphorous load by 10% to 15%. If the PAD process is not implemented, it is recommended that the existing aerobic digesters be aerated intermittently to reduce the sidestream nitrogen and

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phosphorous load. OWRF staff have previously operated the existing aerobic digesters using a PAD operational strategy for a short duration. Average phosphorous removal of 20% was observed during this testing. Based on these results, and the existing facility being equipped with all of the equipment necessary to operate the aerobic digesters as PAD reactors, it is recommended that the system be run using a PAD operational strategy once the existing blowers can be replaced to provide stable operation.

5.3.2 Struvite Precipitation

Anaerobic digesters release phosphorous, ammonia and magnesium from digested solids. If the pH of the digested solids is in the range of 7.5 to 8.5, magnesium ammonium phosphate, or struvite is formed. Struvite precipitation removes phosphorus and ammonia released during anaerobic digestion, reducing the side stream phosphorous and ammonia load. Also, struvite can be harvested from sludge and used as an alternative to rock phosphate fertilizer. This process has been commercialized to produce high phosphate fertilizer in some facilities where an adequate quantity of struvite can be formed. More typically, the struvite crystals formed within the sludge are conveyed with the sludge to the dewatering process. Operating data at facilities that utilize this process indicate that digested sludge with stabilized struvite experience improved dewaterability.

Sufficient magnesium and a means to raise the pH is required for struvite precipitation. In full scale processes, magnesium chloride is fed to the reactor to meet the magnesium requirement and CO₂ is purged from the solids stream using blowers or vacuum systems to raise the pH. To mimic the performance of a struvite precipitation system, the process model was configured to include magnesium chloride feed and the feed of sodium hydroxide to the existing aerobic digesters. The model indicates successful struvite precipitation, reducing phosphorous and ammonia concentrations within the sidestream. The performance of the system is reliant on various factors such as magnesium to phosphate (Mg:PO₄) molar ratio, pH, aeration rate, and reactor types. A bench scale or demonstration level study is suggested to predict the actual performance of a struvite precipitation system and determine whether this process is a viable option for the facility. A demonstration project is currently in operation at the Provo Water Reclamation Facility (PCWRF) that is showing promising results.

Implementing a struvite precipitation treatment alternative will require a significant capital investment at the OWRF. Few commercial processes are available that can be implemented for struvite precipitation. These technologies are described in the following sections.

5.3.2.1 Ovivo Elovac

Ovivo's controlled struvite precipitation technology feeds includes magnesium chloride feed into a reactor that is place under vacuum pressure to raise the pH. Provo City is conducting a full-scale demonstration study of the technology at the PCWRF. The system is producing an average phosphorus reduction of more than 85% TP concentrations less than 25 mg/L in the sidestream. Figure 4 is a schematic of the Elovac technology.

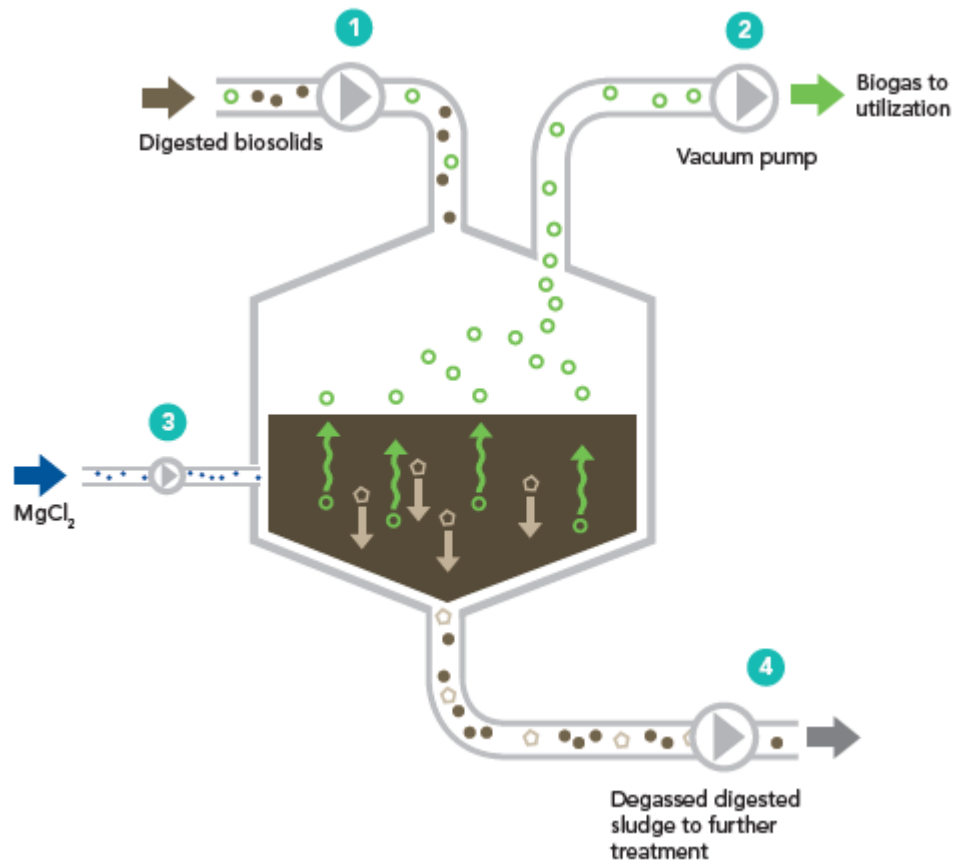


Figure 4 Ovivo's Elovac Schematics

5.3.2.2 Centrisys Magprex

In Centrisys's Magprex system (previously known as Airprex), anaerobically digested sludge is fed to a reactor that is equipped with a coarse-bubble aerator. The introduction of air strips out the CO_2 within the biosolids, increasing the pH to approximately 8.0. Magnesium chloride is fed to the reactor to provide the necessary magnesium to form struvite crystals within the reactor. Once the crystals are heavy enough, they settle to the bottom of the reactor. There are multiple successful full-scale implementations of this technology. Figure 5 is a schematic of this technology. Modification of this process, the Ostara Pearl and Ostara WASSTRIP, have been developed to promote the production of a commercial fertilizer from the struvite formed in the reactor. These systems include modifications that promote the growth of the struvite crystals into pellets large enough to be separated and packaged for resale.

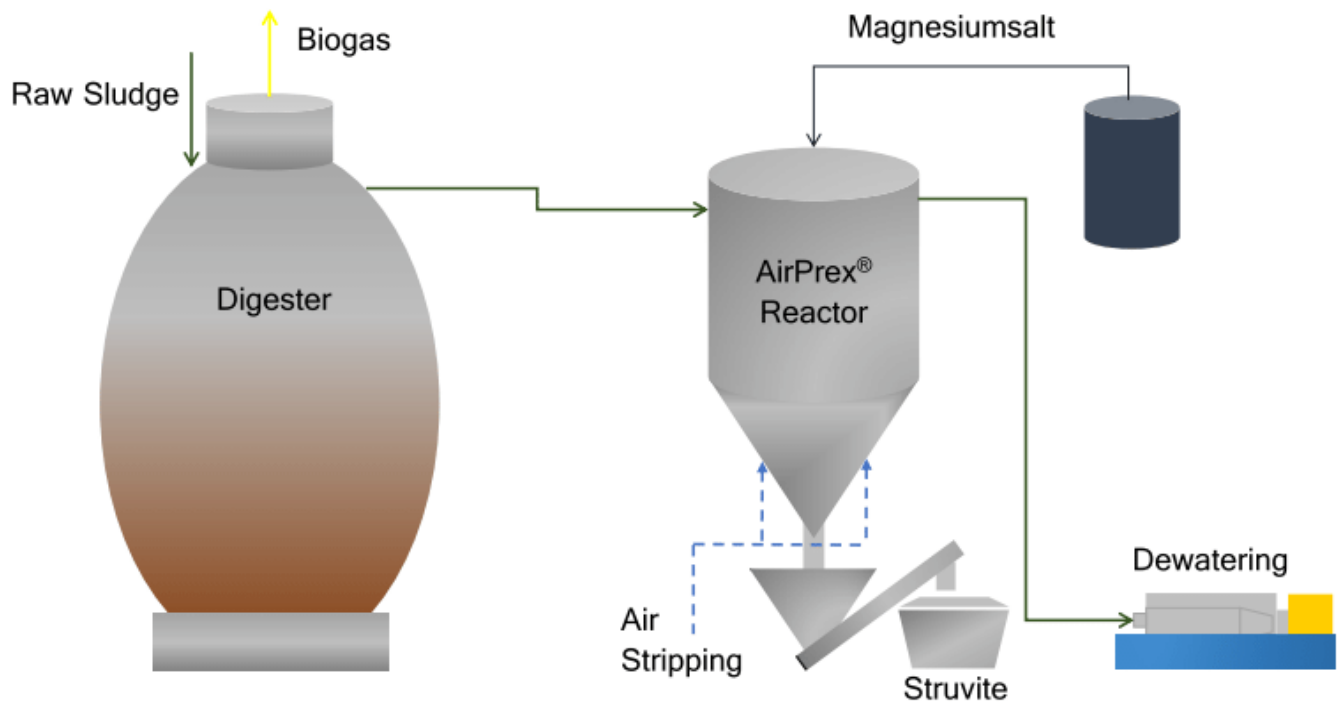


Figure 5 Centrisys's Magprex (previously known as Airprex) Schematics

6. Summary of Process Modification and Treatment Options

Table 9 summarizes the process modifications and treatment options discussed in this technical memorandum.

Table 9 Summary of Process Modification and Treatment Options

Treatment Process Option ¹	Brief Process Description	Model Predicted Results ²
Current Treatment Process Modifications		
Ammonia Based Aeration Control (ABAC)	Dissolved oxygen in the bioreactors is controlled to limit nitrification to meet, but not exceed, effluent ammonia requirements. This will reduce dissolved oxygen, nitrate and nitrite in the RAS and prevent poisoning of the anaerobic basins.	BOD: < 5 mg/L TSS: < 10 mg/L NH ₃ : 1.8 to 3.4 mg/L TIN: 3.9 to 10.5 mg/L TP: 1.2 to 1.5 mg/L
RAS Flow Control	RAS flow control and measurement will be provided and/or automated to provide adequate operational control.	
Treatment Process Alternative ³		
Post Aerobic Digestion (PAD)	Anaerobically digested sludge is intermittently aerated creating alternating aerobic and anaerobic/anoxic conditions. This process will reduce the ammonia and phosphorous load in the sidestream recycle from the solids processing system. Process modeling indicates that PAD will be carbon limited and may need a calcium or magnesium supply. If primary sludge feed to the PAD reactor is implemented to supplement carbon, Class A biosolids will not be achieved. Due to exocellular polymeric substances destruction, sludge dewaterability may be improved.	BOD: < 5 mg/L TSS: < 10 mg/L NH ₃ : 0.6 to 2.5 mg/L TIN: 3.7 to 10.3 mg/L TP: 0.9 to 1.1 mg/L
Struvite Precipitation	Increase the pH in the anaerobically digested sludge and feed magnesium chloride. This process will reduce the ammonia and phosphorous load in the sidestream recycle from the solids processing system. Proven full scale commercial struvite precipitation technologies are available for implementation.	BOD: < 5 mg/L TSS: < 10 mg/L NH ₃ : 1 to 3.6 mg/L TIN: 4.8 to 9.9 mg/L TP: 0.9 to 1.1 mg/L
Partial Bypass of Primary Influent to Bioreactors and Post Aerobic Digestion	Primary influent is bypassed directly to the bioreactors to supplement carbon required for biological phosphorous removal and denitrification. Treatment process may experience increased solids production and solids stream treatment process may operate at capacity. PAD is implemented to reduce phosphorous and ammonia load from the sidestream.	BOD: < 5 mg/L TSS: < 10 mg/L NH ₃ : 1.9 to 3.2 mg/L TIN: 5.5 to 8.4 mg/L TP: 0.6 to 0.8 mg/L
Partial Bypass of Primary Influent to Bioreactors and Struvite Precipitation	Primary influent is bypassed directly to the bioreactors to supplement carbon required for biological phosphorous removal and denitrification. Treatment process may experience increased solids production and solids stream treatment process may operate at capacity. Struvite precipitation is implemented to reduce the phosphorous load from the sidestream.	BOD: < 5 mg/L TSS: < 10 mg/L NH ₃ : 1 to 4 mg/L TIN: 3.8 to 8.8 mg/L TP: 0.7 to 0.9 mg/L
Partial Bypass of Primary Influent to Bioreactors and Aluminum Sulfate Addition to Belt Filter Press Feed	Primary influent is bypassed directly to the bioreactors to supplement carbon required for biological phosphorous removal and denitrification. Treatment process may experience increased solids production and solids stream treatment process may operate at capacity. Phosphorous is precipitated using aluminum sulfate to reduce the phosphorous load from the sidestream.	BOD: < 5 mg/L TSS: < 10 mg/L NH ₃ : 1.5 to 3.4 mg/L TIN: 2.5 to 6.5 mg/L TP: 0.6 to 0.9 mg/L

Treatment Process Option ¹	Brief Process Description	Model Predicted Results ²
Primary Sludge Fermentation and Post Aerobic Digestion	Primary sludge is thickened and fermented. Fermentation of volatile suspended solids (VSS) will create volatile fatty acids (VFAs). Supernatant with mixed VFAs from the thickener/fermenter is sent to the bioreactors supplementing carbon required for phosphorus removal and denitrification. PAD is implemented to reduce the phosphorous and ammonia load from the sidestream.	BOD: < 5 mg/L TSS: < 10 mg/L NH3: 1.2 to 3 mg/L TIN: 3.6 to 9.25 mg/L TP: 0.6 to 0.8 mg/L
Primary Sludge Fermentation and Struvite Precipitation	Primary sludge is thickened and fermented. Fermentation of volatile suspended solids (VSS) will create volatile fatty acids (VFAs). Supernatant with mixed VFAs from the thickener/fermenter is sent to the bioreactors supplementing carbon required for phosphorus removal and denitrification. Struvite precipitation is implemented to reduce the phosphorous load from the sidestream.	BOD: < 5 mg/L TSS: < 10 mg/L NH3: 0.4 to 2 mg/L TIN: 6.7 to 10.5 mg/L TP: 0.4 to 0.7 mg/L
Primary Sludge Fermentation and Aluminum Sulfate Addition to Belt Filter Press Feed	Primary sludge is thickened and fermented. Fermentation of volatile suspended solids (VSS) will create volatile fatty acids (VFAs). Supernatant with mixed VFAs from the thickener/fermenter is sent to the bioreactors supplementing carbon required for phosphorus removal and denitrification. Phosphorous is precipitated using aluminum sulfate to reduce the phosphorous load from the sidestream.	BOD: < 5 mg/L TSS: < 10 mg/L NH3: 2 to 3.3 mg/L TIN: 4.3 to 9.95 mg/L TP: 0.7 to 0.9 mg/L
Notes: 1. It is assumed that solids stream process will be operated as per design to thicken primary sludge and waste activated sludge (WAS) to 3%. 2. The results reflect performance of treatment process for ADMM load during summer and winter temperature. Effluent ammonia during winter temperature was kept below 2.5 mg/L and during summer temperature was kept below 4 mg/L. 3. It is assumed that ammonia based aeration control process and RAS flow split control will be implemented in mainstream process.		

7. PFAS Treatment

Currently available wastewater treatment technologies including those discussed above, are generally ineffective for the removal of PFAS. The applicability of advanced technologies to remove PFAS from wastewater, based on physical separation or destruction techniques, is currently being investigated in pilot projects throughout the US. The preliminary results indicate that the large-scale removal of PFAS in wastewater treatment plants will not be economically nor environmentally viable in the near term.

Utah DWQ states that PFAS compound production has not been undertaken within Utah, but many industries in the state likely use PFAS in their manufacturing processes. Military installations and airports in the state have likely used firefighting foam that contains PFAS. Thus, it is recommended that OWRP conduct a survey of its industrial influent streams and leachate streams, if any, to detect sources of PFAS and measure PFAS concentrations using current available measurement methods. This will allow the City to assess treatment for PFAS at the source rather than treat at facility.

Several of the available treatment technologies already applied by drinking water suppliers are currently under investigation for wastewater at the lab/pilot scale. Treatment of PFAS in biosolids will be discussed in the *Management of Biosolids Technical Memorandum*. Selected technologies for PFAS removal and destruction under investigation are described here.

7.1 Physical Adsorption/Separation Technologies for PFAS Removal

Physical separation technologies include adsorption to powdered activated carbon (PAC), granular activated carbon (GAC), or to ion-exchange resins (IEX), and separation with high-pressure membrane filtration such as nanofiltration (NF) or reverse osmosis (RO). The effectiveness of removal with each of these technologies largely depends on the concentration of the PFAS in the influent as well as on specific operational conditions.

7.1.1 Adsorption

PFAS in wastewater has been shown to react with powdered activated carbon (PAC) or granular activated carbon (GAC) resulting in the removal of a portion of the PFAS. Residence time and concentration of other organic ions have a significant impact on the removal efficiency (yields of greater than 70% have been reported). GAC is currently the best technique for the longer-chain PFAS molecules such as PFOA, but GAC is less effective for the short-chain PFAS molecules. The efficacy of GAC is hindered by relatively rapid depletion of the GAC since PFAS does not degrade biologically after adsorption, so reactivation is required.

Ion-exchange (IEX) is a somewhat promising alternative for the shorter-chain PFAS molecules. The adsorbents (resins) are more expensive than GAC, but improved operational conditions may make the process more cost-effective in the long term. Residence time and concentration of inorganic ions have an impact on the removal efficiency.

7.1.2 Separation techniques

Both nanofiltration (NF) and reversed osmosis (RO), two high-pressure membrane filtration techniques, are effective for PFAS removal offering greater than 70% removal depending on

transmembrane pressure and membrane fouling. Ultrafiltration has been found to provide insufficient removal of 0-20%.

7.1.3 Foam (oxo) fractionation

Foam fractionation is a possible alternative. PFAS compounds have natural physiochemistry to adhere to fine air bubbles rising through a narrow water column. As the bubbles rise, they are exceptionally effective in collecting PFAS compounds which are loosely bound to the water molecules. The PFAS compounds accumulate at the top of the column as a rich foam that can be separated. The relatively low volume of PFAS concentrate that the system produces can be directed to a low-pressure evaporation process that distills and reduces the waste stream to create a PFAS hyper-concentrate.

More than 70% PFAS removal through physical separation technologies has been observed in isolated studies. The drawback of these physical separation technologies, besides being expensive, is that they do not destroy PFAS but only remove it from the contaminated water and produce a PFAS-contaminated waste stream (adsorbents or concentrated brines). The disposal of these streams may pose secondary pollution risks and problems.

7.1.4 PFAS Destruction

There are also destructive technologies for use with PFAS, based on high-energy incineration or advanced oxidation. These technologies include electrochemical oxidation, microwave thermal treatment, photolytic degradation, pyrolysis, and sonochemistry. These extreme PFAS degradation pathways are very costly, especially when the volume and the flowrate of PFAS wastewater are large. Implementation of these technologies at full scale is currently not viable.

APPENDIX D. **Biosolids Management Technical Memorandum**



OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
BIOSOLIDS MANAGEMENT TECHNICAL MEMORANDUM - DRAFT

OREM WATER RECLAMATION FACILITY

CAPITAL IMPROVEMENT MASTER PLAN

BIOSOLIDS MANAGEMENT TECHNICAL MEMORANDUM - DRAFT

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Table of Contents

Executive Summary.....	4
1 Introduction	6
2 Background	6
2.1 Biosolids Sources	6
2.1.1 Design, Current, and Projected Primary Sludge and Waste Activated Sludge Production ..	6
2.2 Design, Current, and Buildout Digested Sludge Production	9
2.3 Design, Current, and Projected Dewatered Sludge Production	11
2.4 Dewatering System and Polymer Usage	11
3 Existing Facilities	11
3.1 Primary Sludge and Scum Pumping	15
3.2 Waste Activated Sludge (WAS) and Secondary Scum Pumping	16
3.3 Dissolved Air Floatation Thickener (DAFT).....	17
3.4 Thermophilic EQ (TEQ) Basin	17
3.5 Staged Solids Digestion Process	18
3.5.1 Thermophilic Anaerobic Digester with Plug Flow Reactor	19
3.5.2 Mesophilic Anaerobic Digesters	19



3.5.3	Hot Water Boiler System and Heat Exchangers	20
3.5.4	Biogas System	23
3.6	Sludge Holding Tanks	24
3.7	Belt Filter Presses for Dewatering Digested Sludge	24
4	Regulatory Requirements	25
5	Improvement Alternatives for Biosolids Management and Processing	33
5.1	Alternative 1 - Provide Improvements to Existing Anaerobic Digestion System to Reliably Achieve Class A or B Biosolids	34
5.1.1	Thickening, Conveyance and Heating Improvements	36
5.1.2	Construct New Digester Volume	37
5.2	Alternative 2 - Construct Pyrolysis Based Sludge Drying System	37
5.3	Alternative 3 – Control of Phosphorous and Nitrogen Return Stream Loadings	38
5.3.1	Improvements to Existing Solids Storage Facilities	38
5.3.2	Construct New Patented Sequestration System to Reduce Phosphorous in Dewatering Return Flows	38
5.4	Alternative 4 - Construct Facilities to Produce Commercial Grade Biofuel for City Fleet Vehicles.	38

List of Tables

Table 2-1 – Design, Current, and Projected Primary Sludge and Scum Production and Characteristics ...	7
Table 2-2 – Design, Current, and Projected WAS and Thickened WAS Production and Characteristics ...	8
Table 2-3 – Pre-Digestion Sludge Characteristics under Current Operating Conditions	9
Table 2-4 – Design, Current, and Buildout Digested Sludge Production and Characteristics	10
Table 2-5 – Design, Current, and Buildout Dewatered Sludge Production and Characteristics	11
Table 3-1 – Primary Sludge and Scum Pumping Design Criteria	15
Table 3-2 – WAS and Secondary Scum Pumping Design Criteria	16
Table 3-3 – DAFT TWAS Design Criteria	17
Table 3-4 – TEQ Basin Pumping Design Criteria	18
Table 3-5 – Staged Digestion System Design Criteria	18

Table 3-6 –Thermophilic Digestion Feed Sludge Design Criteria.....	19
Table 3-7 –Thermophilic Digestion System Design Criteria.....	19
Table 3-8 –Mesophilic Digestion Design Criteria	20
Table 3-9 –Thermophilic Digestion Process Pump Design Criteria.....	21
Table 3-10 - Thermophilic Sludge to Sludge Heat Exchanger (HE1) Design Criteria	21
Table 3-11 - Thermophilic Sludge to Water Heat Exchanger (HE2) Design Criteria	22
Table 3-12 – Plug Flow Reactor Heat Exchanger (HE3) Design Criteria.....	22
Table 3-13 –Thermophilic Boiler System Design Criteria	22
Table 3-14 –Sludge Holding Tank Sizing	24
Table 3-15 –Belt Filter Press System Design Criteria	25
Table 4-1 – Requirements for Achieving Class A and Class B Biosolids Pathogen and to Vector Attraction Reduction	26
Table 4-2 – OWRF Digester Complex Volumes and Available SRTs at Current and Projected Loads	28
Table 4-3 – OWRF UPDES Permit Pathogen Monitoring Results.....	30

List of Figures

Figure 3-1 OWRF Solids Stream Process Flow Diagram.....	13
Figure 3-2 OWRF Biogas Process Flow Diagram	14

Executive Summary

This technical memorandum contains the following:

- Orem Water Reclamation Facility (OWRF) biosolids volume generated and characteristics (present and projected) evaluations; Flows and loads (present and projected) – for all proposed solids stream treatment options, including processing and handling of chemical sludge created with chemical phosphorous removal.
- Outline of existing OWRF related Biosolids Facilities and current equipment and tankage configurations employed.
- Summary of the current OWRF Biosolids related regulations
- Provides a biosolids management approach that discusses needs and options to address current and future solids generation scenarios as well as chemical sludge processing and disposal.

Key findings of this memorandum include:

1. Under current conditions, OWRF can produce biosolids that consistently demonstrate pathogen reduction levels that meet Class A or B Biosolids requirements. OWRF also maintains sufficient volatile solids destruction of greater than 38% and maintains a minimum overall digestion solids retention time (SRT where for digestion $SRT = \text{Hydraulic Residence Time (HRT)}$) of 15-days to meet Class A or B Biosolids vector attraction requirements. OWRF produced biosolids contain residual metals levels that achieve exceptional quality biosolids requirements.
2. However, OWRF staff are challenged to maintain a consistent design 3% solids sludge feed into the digesters due to both thickening equipment, sludge heating and pumping challenges.
3. As OWRF flows and loads increase and with continued feed of diluted feed sludges (at 1 to 2% solids) into the digestion process, OWRF will not be able to meet EPA solids residence time (SRT) requirements for pathogen reduction and vector attraction for either Class A or B biosolid production at buildout design flows.
4. If any digester is taken out of service at current flows and loads, OWRF will not meet EPA SRT requirements for Class B Biosolids with regards to vector attraction. In this case, the biosolids would then not be suitable for land application per EPA requirements and OWRF would have to landfill the biosolids.

-
5. If the thermophilic digester is taken out of service at current flows and loads, OWRF will not meet EPA SRT requirements for Class A with regards to vector attraction and pathogen reduction or Class B Biosolids requirements with regards to vector attraction. Also, with the thermophilic digester out of service, Class A biosolids would not be able to be produced as the high temperature operation of this digester is required to meet EPA pathogen reduction requirements for Class A Biosolids.

The following solids planning alternatives have been developed to address the EPA biosolid SRT challenges as flows and loads increase, provide enhanced capability to produce Class B Biosolids or Class A Biosolids for future biosolids uses, accomplish reduction reporting requirements, and address future biosolids contaminants of concern that may become regulated:

1. Provide improvements to the existing anaerobic digestion system to maintain Class B Biosolids production and provide reliable capability to achieve class A Biosolids
2. Construct new digester volume to provide redundancy and facilitate digester maintenance while meeting EPA SRT requirements
3. Provide improvements to the existing solids storage facilities to control dewatering, nitrogen, and phosphorous return stream flows to the liquid stream process
4. Construct new patented sequestration system to remove phosphorous from dewatering return flows back into the liquid stream process
5. Construct new based pyrolysis drying facility to address future contaminant of concern regulations and expand biosolids use options while reducing wet tons of biosolids produced, and
6. Construct facilities to produce commercial grade biofuel for city fleet vehicles to provide resource recovery capability to the OWRF anaerobic digestion system.

Costs and further descriptions of these solids related alternatives will be further elaborated in the Master Plan document.

1 Introduction

This memorandum presents the evaluation of Biosolids management at Orem Water Reclamation Facility (OWRF). The evaluation memorandum is broken into the following sections:

- Section 2 – Background – This section describes the sources for biosolids and biosolids produced at OWRF along with current and predicted volumes and percent solids levels.
- Section 3 – Existing Facilities – This section describes the key components and design criteria of the OWRF solids handling facilities
- Section 4 – Regulatory Requirements – This section reviews the OWRF permit requirements to produce Class A or B Biosolids
- Section 5 – Identify Improvements Alternatives for Biosolids Management and Processing

2 Background

Biosolids are a product of the wastewater treatment process. During wastewater treatment the liquids are separated from the solids. Those solids are then treated physically and chemically to produce a semisolid, nutrient-rich product known as biosolids.

Biosolids conditioned for beneficial use must meet federal and state requirements. Examples of beneficial use include application to agricultural land and reclamation sites (e.g., farms, mining sites). When applied to land at the appropriate agronomic rate, biosolids provide several benefits including nutrient addition, improved soil structure, and water use. Land application of biosolids provides economic and waste management benefits, including conservation of landfill space; reduced demand on non-renewable resources like phosphorus; and a reduced demand for synthetic fertilizers.

2.1 *Biosolids Sources*

Waste solids streams that contribute to biosolids production includes:

- Primary sludge (PS) and scum generated by the primary clarification process.
- Waste activated sludge (WAS) and scum collected from the secondary clarification process.

PS and WAS could contain metal salt precipitates generated by alum addition for chemical phosphorous removal.

2.1.1 **Design, Current, and Projected Primary Sludge and Waste Activated Sludge Production**

PS and WAS flows and loadings have been developed for three conditions including facility basis of design, current operating conditions, and buildout conditions. The current conditions data were obtained from the facility process data records and the buildout data were calculated using Biowin modeling. PS solids production and characteristics are listed in Table 2-1 and WAS and thickened WAS production and characteristics are listed in Table 2-2.

Table 2-1 – Design, Current, and Projected Primary Sludge and Scum Production and Characteristics

Parameter	Current Facility Design	Current Average Daily	Buildout Design ADMM Loading Condition	
			Typical Load Condition with Reduced Thickening from Treatment Process Evaluation Modeling	Typical Load Condition with Thickening Near 3% from Treatment Process Evaluation Modeling
Mass Flow from Primary Clarification, ppd	19,700	9,600	11,840	13,000
Volumetric Flow from Primary Clarifiers, gpd	78,700	113,000	170,000	70,000
Primary Clarifier Solids, %	3.00	1.02 ¹	0.84	2.24
¹ Current solids loading rates are calculated as averages of current OWRF flows and loads data. The projected solids loading is calculated based on a “worst-case” scenario of average annual day flow with average day maximum month solids loading. A higher overall loading concentration produces a thicker sludge when the process equipment is operated similarly.				

Table 2-2 – Design, Current, and Projected WAS and Thickened WAS Production and Characteristics

			Buildout Design ADMM Loading Condition ¹	
			Typical Load Condition with Reduced Thickening from Treatment Process Evaluation Modeling	Typical Load Condition with Thickening Near 3% from Treatment Process Evaluation Modeling
	Current Facility Design	Current Average Daily¹		
WAS Mass Flow, ppd	15,560	7,000	15,100	13,600
WAS Volumetric Flow, gpd	264,600	161,000	400,000	400,000
WAS Solids, % as TSS	1.0	0.52	0.45	0.41
DAF Thickened WAS Mass Flow, ppd	22,100	4,900	16,000	26,600
DAF Thickened Volumetric Flow, gpd	88,200	30,000	140,000 ³	110,000 ³
DAF Thickened WAS Solids Content, %	3.0	2.1 ²	2.36 ³	2.83 ³
¹ Current solids loading rates are calculated as averages of current OWRF flows and loads data. The projected solids loading is calculated based on a “worst-case” scenario of average annual day flow with average day maximum month solids loading. A higher overall loading concentration produces a thicker sludge when the process equipment is operated similarly. ² WAS Thickening Only at Dissolved Air Flotation Thickener (DAFT) ³ Cothickening of PS and WAS in DAFT				

In addition to the above table, OWRF staff has been tracking sludge feed characteristics of combined sludge feeds (primary sludge, primary scum, WAS, and secondary scum) from the Thermophilic EQ (TEQ) basin into the Thermophilic digester via their total annual pre-digestion production spreadsheets. This data is summarized as follows:

Table 2-3 – Pre-Digestion Sludge Characteristics under Current Operating Conditions

Year	Total Sludge/Scum Discharge Volume from TEQ to Digestion, gal	Average Daily Sludge Flow Discharge Flow from TEQ to Digestion, gpd	% Solids Range for Digester Feed	Average % Solids for TEQ Sludge	Pre-Digested Sludge Mass Feed to Digestion, Dry Metric Tons (DMT)
2016	39,718,556	108,800	1.21 - 2.14	1.52	2,284
2017	35,188,845	96,408	1.18 - 3.04	2.19	2,909
2018	40,608,867	111,260	1.16 - 3.19	2.11	3,239
2019	35,554,232	97,409	0.83 – 3.21	1.52	2,049
2020	25,960,405	98,252	1.51 – 2.99	2.69	3,655

They key item to note from the above table is the feed sludge percent solids into the digesters which is consistently below the current design feed solids of 3%. Following sections will discuss operational challenges encountered by OWRF staff in maintaining a consistent 3% design solids feed into the digesters.

2.2 Design, Current, and Buildout Digested Sludge Production

OWRF biosolids are produced in the form of dewatered, anaerobically digested sludge. Digested sludge is produced by feeding primary sludge, primary scum, secondary scum, and thickened WAS into an anaerobic solids digestion process. The digested solids are then dewatered using belt filter presses.

The current OWRF solids stream process was modeled using Biowin™ process modeling software, and the model was calibrated based on current and historical biosolids OWRF data. Buildout biosolids production and characteristics were projected using current and historical biosolids production coupled with buildout design conditions for liquid stream systems based on biological phosphorous removal and chemical phosphorous removal. OWRF flows and loads information is detailed in the Flows and Loads technical memorandum and OWRF Biowin™ modeling is summarized in the Process Evaluation technical memorandum.

Thermophilic and mesophilic digested solids production and characteristics are listed in Table 2-4.

Table 2-4 – Design, Current, and Buildout Digested Sludge Production and Characteristics

Parameter	Current Design	Current Average Daily	Buildout Design ADMM Loading	
			Typical Solids Load Condition with Reduced Thickening from Treatment Process Evaluation Modeling Memo	Typical Solids Load Condition with Thickening Near 3% from Treatment Process Evaluation Modeling Memo
Thermophilic Digester TSS Mass Flow, ppd	41,800	16,400	26,860	26,600
Thermophilic Digester Volumetric Flow, gpd	167,000	150,000	140,000	110,000
Thermophilic Digester Feed TSS Content, %	3.0	1.3	2.36	2.8
Achievable Thermophilic SRT, days	6	6.6	7.3	8.9
Mesophilic Digester Mass Flow, ppd	41,800	8,930	14,100	15,800
Mesophilic Digester Volumetric Flow, gpd (gpm)	167,000	150,000	140,000	110,000
Mesophilic Digester Solids Content, %	3	0.7	1.2	1.7
Achievable Mesophilic SRT, days	8	11.2	10.2	12.4

2.3 Design, Current, and Projected Dewatered Sludge Production

Design capacity, current and projected digested solids production and characteristics are listed in Table 2-5.

Table 2-5 – Design, Current, and Buildout Dewatered Sludge Production and Characteristics

	Current Design	Current Average Daily	Buildout Design ADMM Loading	
			Solids Load Condition with Reduced Thickening	Solids Load Condition with Thickening Near 3%
Digested Solids TSS Mass Flow, ppd	25,100	9,050	17,300	17,000
Digested Solids Volumetric Flow, gpd	167,000	150,000	130,000	110,000
Digested Solids Content, %	1.8	0.7	1.3	1.7
Dewatered Solids Total Wet Mass, ton/day	70	27	55	52
Dewatered Solids Dry Mass, ton/day (ppd)	12.6	4.32	8.7	8.5
Dewatered Solids Volume, cy / day	83	32	65	61.6
Dewatered Sludge Solids Content, %	18.0	16.0	15.7	16.3

2.4 Dewatering System and Polymer Usage

Polymer is applied to the digested solids to improve dewaterability of digested sludge fed into the belt filter presses. OWRF staff are planning to replace some or all belt press units in the near future with screw presses. Therefore, polymer usage and belt press solids treatment capacity will not be examined in depth at this time. However, if the OWRF decides to continue employing belt press units then polymer usage data will be obtained to examine polymer usage and belt press capacity.

3 Existing Facilities

OWRF solids stream processes and corresponding design parameters are described in detail in the following subsections:

- Primary Sludge (PS) and Scum Pumping
- Waste Activated Sludge (WAS) and Secondary Scum Pumping

-
- Dissolved Air Flotation (DAF) Thickening of Secondary Clarifier Scum and WAS
 - Thermophilic Equalization (TEQ) Basin
 - Thermophilic Anaerobic Digester with Plug Flow Reactor
 - Mesophilic Anaerobic Digesters
 - Digester Biogas Gas Collection System
 - Hot Water Boiler System and Heat Exchangers
 - Sludge Storage Tanks
 - Dewatering Polymer Feed System and Belt Filter Presses for Dewatering Digested Sludge

Process flow diagrams for the OWRF solids stream and for the digester gas stream are shown in Figures 3.1 and 3.2, respectively.

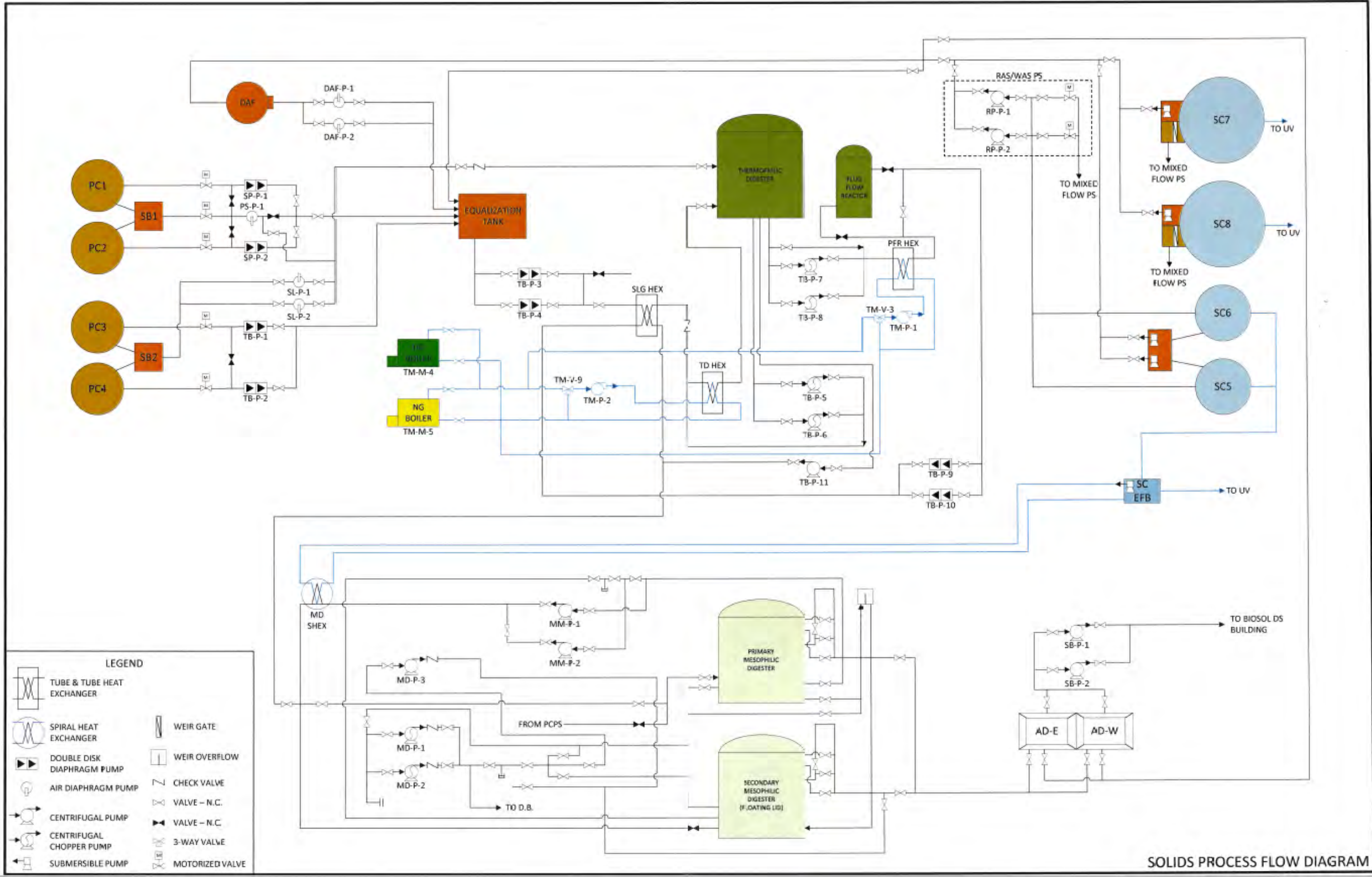


Figure 3-1 OWRF Solids Stream Process Flow Diagram

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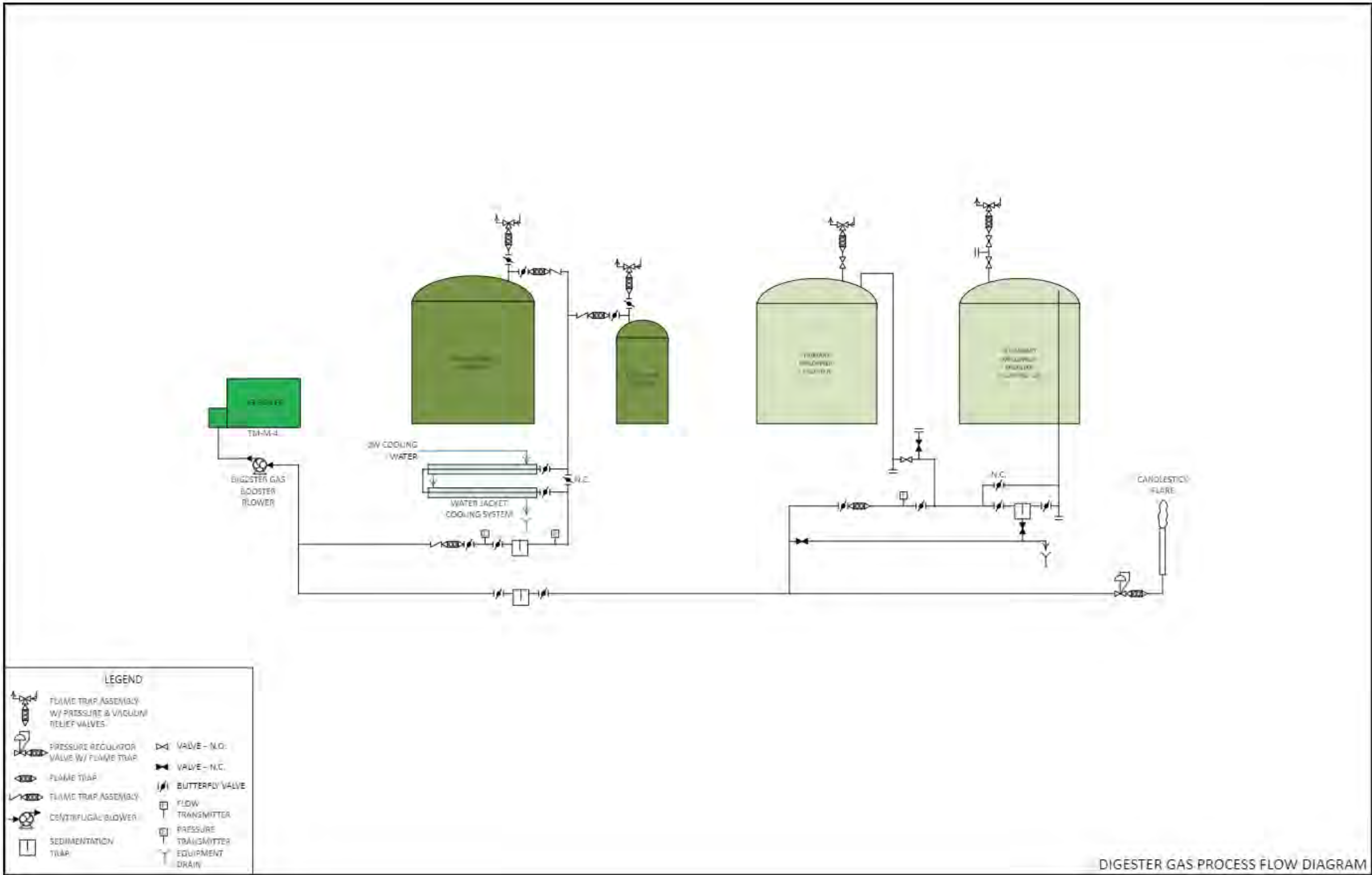


Figure 3-2 OWRF Biogas Process Flow Diagram

3.1 Primary Sludge and Scum Pumping

Primary Sludge and Scum is pumped from the primary clarifiers to the TEQ Basin where it mixes with WAS and Secondary Scum from OWRP's secondary process. The combined flows in the TEQ Basin are then pumped to the anaerobic digestion process. The primary sludge and scum pump stations are equipped with the equipment detailed in Table 3-1 below.

Table 3-1 – Primary Sludge and Scum Pumping Design Criteria

Description	Value
Primary Clarifiers No. 1 and No. 2	
Number of Sludge Pumps ¹	2
Pump Type (Manufacturer) ¹	Double Disc, Positive Displacement (Penn Valley)
Design Flow, gpm	52-104
Design TDH	25
Number of Scum Pumps ¹	1
Pump Type (Manufacturer) ¹	Diaphragm (Andronaco Industries RamParts)
Design Pump Station Flow, gpm	9.8-94
Design TDH	20-150
Flowmeter	1 Magnetic for Primary Clarifier No. 1 (Tag FE-0931) 1 Magnetic for Primary Clarifier No. 2 (Tag FE-0922C) Flow for scum is calculated by number of pump strokes
Primary Clarifiers No. 3 and No. 4	
Number of Sludge Pumps ²	2
Pump Type (Manufacturer)	Double Disc, Positive Displacement (Penn Valley)
Design Flow, gpm	52-104
Design TDH	25
Flowmeter	1 Magnetic for Primary Claifiers No. 3 and No. 4 (Tag FE-991: measures combined sludge flow) Flow for scum is calculated by number of pump strokes
Number of Scum Pumps ²	2
Pump Type (Manufacturer)	Diaphragm (Andronaco Industries RamParts)
Design Pump Station Flow, gpm	9.8-94
Design TDH	20-150
¹ Sludge and scum pumps are hydraulically linked to allow the sludge and scum streams to be pumped by any of the three pumps. ² Sludge pumps are hydraulically linked to allow the sludge stream to be pumped by either pump for clarifiers 3 & 4. Scum systems are not hydraulically linked.	

The 2010 OWRF Upgrades Design indicates that primary sludge was designed to be thickened to 3% solids. However, OWRF staff have indicated that the pumps are not able to pump primary sludge with solids content higher than 1.2% solids. OWRF staff have indicated the pumps do not provide adequate suction lift or that there is a restriction on the suction side of the pumps. Primary solids are typically thickened to 0.6% to 1.2% concentration. Table 2-1 shows the design, average current, and projected primary sludge and scum characteristics based on design data, current operations data, and buildout conditions. This data indicate that even at current loads, the primary sludge and scum flow exceed the facility design volumetric flow rate.

3.2 Waste Activated Sludge (WAS) and Secondary Scum Pumping

WAS is drawn from SC No. 5 and No. 6 only, and flows to the Dissolved Air Flotation Thickener (DAFT) before being pumped to the TEQ Basin and the thermophilic digestion process. WAS cannot be wasted from SC No. 7 or SC No. 8. SC No. 7 and No. 8 each have a dedicated RAS box and scum box. A weir allows scum to overflow from the RAS box. A normally closed slide gate between each RAS box and scum box may be used to allow secondary sludge to flow to the scum box. A submersible pump in each scum box conveys flow to the DAFT.

SC No. 5 and No. 6 share a scum box equipped with two (2) submersible pumps to convey scum flow to the DAFT. SC No. 5 and No. 6 RAS/WAS Pump Station is equipped with two centrifugal pumps which pump WAS to the DAFT. Thickened WAS is pumped from the DAFT to the TEQ basin by two air diaphragm pumps.

The OWRF process is equipped with the operational flexibility to bypass the DAFT and deliver WAS and secondary scum directly to the TEQ Basin or to the Sludge Holding Tanks No. 1 and No. 2 (previously operated as Aerobic Digesters and discussed in Section 3.5.4). Table 3-2 describes the design criteria for the WAS and secondary scum pumping.

Table 3-2 –WAS and Secondary Scum Pumping Design Criteria

Criteria	Value
SC No. 5 and No. 6 WAS Pumps	
Number of WAS Pumps	2
Pump Type (Manufacturer)	Centrifugal
Flowmeter	Magnetic – Tag FE-321
SC No. 5 and No. 6 Scum Pumps	
Number of Scum Pumps	2
Pump Type (Manufacturer)	Submersible
SC No. 7 Scum Pump	
Number of Scum Pumps	1
Pump Type (Manufacturer)	Submersible
SC No. 8 Scum Pump	
Number of WAS Pumps	1
Pump Type (Manufacturer)	Submersible

The 2010 OWRF upgrades design assumes that WAS should be thickened to 1% in the clarifiers. Facility data indicates that WAS is currently thickened to approximately 0.5% in the secondary clarifiers. Operators have not reported problems with the current WAS pumping system.

3.3 Dissolved Air Floatation Thickener (DAFT)

WAS and scum collected at the OWRF's secondary clarifiers is pumped to the DAFT. Thickened WAS is then typically pumped from the DAFT to the Thermophilic Equalization Tank.

Table 3-3 shows the DAFT pump data. The DAFT was designed to thicken solids to 3%, but it is currently producing thickened WAS (TWAS) with 2.1% solids. Facility staff have indicated that optimizing DAFT operation to thicken WAS to 3-4% solids is preferred. However, if the DAFT thickens solids to 3% then the downstream dewatering process is negatively impacted due to challenges of mixing polymer with digested feed solids above 2%. The DAFT itself has sufficient capacity for the volumetric flow when the solids are thickened at their current rate and may be capable of handling the volumetric flow rate projected for the buildout condition. DAFT thickened sludge pumping design criteria is indicated in Table 3-3. It should be noted that there is no redundancy DAF unit currently installed at OWRF for WAS thickening.

Table 3-3 –DAFT TWAS Design Criteria

Criteria	Value
DAFT TWAS pumps	
Number of Pumps	2
Pump Type (Manufacturer)	Diaphragm (Andronaco Industries RamParts)
Design Flow, gpm	9.8-94
Design TDH, ft	20-150
Flowmeter	None
	Flow for TWAS is calculated by number of pump strokes

3.4 Thermophilic EQ (TEQ) Basin

The purpose of the TEQ basin is to equalize the flowrate conveyed to the solids handling processes. Equalized flow improves process performance both hydraulically and biologically by dampening flow variations and reducing the effects of shock loadings to biological processes.

The TEQ basin receives primary sludge and scum and thickened WAS and secondary scum. If required, operators have the operational flexibility to bypass the DAFT and deliver unthickened WAS and scum directly to the TEQ basin or sludge holding tanks.

OWRF staff report that the newest TEQ basin effluent pumps are undersized, which may be a symptom of insufficient thickening at the primary and secondary processes relative to the system's design. The pumps were designed to operate in a lead-standby configuration, but to pump the current solids volume, both pumps are operated. The lead-standby configuration is preferred because it provides operators adequate redundancy to perform scheduled maintenance and required repairs. TEQ basin pumping data is shown in Table 3-4 below. OWRF staff have also indicated that the TEQ basin was initially designed with a 10-foot operating range. Operating at that range caused significant odor issues which led the

W:\Engineering\Projects\21-027 Orem WRF Improvements Plan_[S]\09 Reports\05 Evaluate Management of Biosolids TM\Biosolids Management TM 220117

operation staff to significantly reduce the operating range to 1 ft. Recently, operators have been experimenting with increasing the operating range to 4 ft without causing odor issues. Although reducing the water depth in the TEQ alleviates the odor issues, it limits the equalization capacity and flow dampening in the TEQ which results in higher flowrates. TEQ basin pumping design criteria is provided below.

Table 3-4 –TEQ Basin Pumping Design Criteria

Criteria	Value
TEQ pumps	
Number of TEQ Pumps	2
Pump Type (Manufacturer)	Double Disk (Penn Valley)
Design Flow, gpm	52-104
Design TDH, ft	25
Flowmeter	1 Magnetic (Tag FE-1015)

3.5 Staged Solids Digestion Process

OWRF is permitted and designed to produce Class A Biosolids. The solids digestion process is staged, with a thermophilic digester followed by a high temperature plug flow reactor, and two mesophilic digesters. The process is designed for a minimum VSS reduction of 40%. A summary of the staged digestion design criteria is provided in Table 3-5.

Table 3-5 –Staged Digestion System Design Criteria

Criteria	Value
Minimum Primary Sludge % Solids Feed to Digester	3
Maximum Primary Sludge Feed Rate at % Solids	78,750 gpd or 55 gpm
Minimum DAF Thickened WAS % Solids Feed	3
Maximum Thickened WAS Digester Feed Rate at Design % Solids	88,200 gpd or 61 gpm
Minimum VSS Reduction, %	40
Minimum VSS Destruction Rate, ppd	11,700
Design SRT based on Design DAF and Primary Sludge Characteristics Listed Above	6
Biogas Production rate, cf/pound VSS	14
Biogas Production rate, cf/day	164,000
¹ Table Source Information: Aqua Engineering WRF General Mass Balance Sheet G-11 dated 02/22/2010	

OWRF is interested in producing Class A Biosolids and employing strategies that prevent landfilling of biosolids even during scheduled maintenance that requires a digester to be taken offline. Regulatory requirements for continuously producing Class A Biosolids or Class B Biosolids are detailed in Section 4. The biogas produced in the digestion process is intended to be fed to the thermophilic boiler system.

3.5.1 Thermophilic Anaerobic Digester with Plug Flow Reactor

The first stage of the digestion process is thermophilic digestion, in which solids are heated to a design temperature of 131 degrees F to allow the production of Class A biosolids and provide superior volatile solids destruction to meet vector attraction requirements. The thermophilic digester was sized for a solids retention time (SRT), of 6 days based on design sludge flows listed in Table 3-5 to achieve Class A pathogen reduction requirements via time and temperature as outlined in Section 4.

Digested solids can then be pumped to the thermophilic plug flow reactor to minimize short circuiting. The sludge in the plug flow reactor is heated to 140 degrees F. The plug flow reactor and heat exchanger HE3 are not currently in operation. Design data for the thermophilic digester and plug flow reactor are outlined in Tables 3-6 and 3-7 below. Digested solids from the thermophilic digester bypass the plug flow reactor and is conveyed to the mesophilic digestion process thru heat exchanger HE1.

Table 3-6 –Thermophilic Digestion Feed Sludge Design Criteria

Criteria	Value
% Feed Solids	3%
Mass Flow Rate, ppd	41,770
Volumetric Flow Rate, gpd	167,000

Table 3-7 –Thermophilic Digestion System Design Criteria

Criteria	Value
Thermophilic Digester	
Quantity	1
Design Temperature, degrees F	131
Total Volume, cf	134,000
Total Volume, gal	1,002,320
Design SRT, days	6
Plug Flow Reactor	
Quantity	1
Diameter, ft	5
Height, ft	30
Design Temperature, degrees F	140
Total Volume, cf	550
Total Volume, gallons	4,100
Design SRT, min	35

3.5.2 Mesophilic Anaerobic Digesters

After the thermophilic digestion process, the solids are cooled and conveyed to the mesophilic digesters No. 1 and No. 2. These digesters are normally operated in series with flow entering the primary digester and then being discharged to the secondary digester. Table 3-8 outlines the design criteria for the

mesophilic digestion process. A recirculation loop is used for cooling the digester solids discharged from the thermophilic digesters to the mesophilic digesters.

After the mesophilic digestion process is complete, the digested solids are decanted from mesophilic digester No. 2 using a barometric loop that draws the biosolids from the bottom of the digester and conveys it to the former aerobic digesters which are now used as sludge holding tanks. Alternately, the sludge holding tanks can be bypassed, with digested solids from mesophilic digester No. 2 discharged directly to the sludge drying beds.

Table 3-8 –Mesophilic Digestion Design Criteria

Criteria	Value
Mesophilic Digesters	
Quantity	2
Design Temperature, degrees F	98
Total Volume, cf (two digesters)	186,000
Total Volume, gallons (two digesters)	1,391,280
Design SRT Days	8

3.5.3 Hot Water Boiler System and Heat Exchangers

Combined solids (thickened WAS, primary sludge, and scum) are pumped from the TEQ basin to the thermophilic digestion process via two tube-in-tube heat exchangers. The first is a sludge-to-sludge heat exchanger (HE1) that heats the solids stream using heated sludge leaving the thermophilic digester and plug flow reactor. At the second heat exchanger (HE2) sludge from the TEQ Basin combines with a recirculation line from the thermophilic digester and is heated to 131 degrees F by water heated from the thermophilic boiler system utilizing either natural gas or digester gas for energy. The process has the ability after thermophilic digestion is completed, to pump the digested solids through a third sludge-to-water tube-in-tube heat exchanger (HE3) which heats the solids to 140 degrees F before they are conveyed to the plug flow reactor. The plug flow reactor is currently being bypassed and therefore the HE3 heat exchanger is not in operation. After thermophilic digestion is complete, the digested solids are pumped to the mesophilic digestion process through HE1 for cooling.

There are three sets of pumps involved in the thermophilic digestion process: two double disk pumps that convey flow from the thermophilic digester or plug flow reactor to HE1; two centrifugal chopper pumps recirculate solids in the thermophilic digester through HE2 to maintain the solids temperature in the digester; and two centrifugal chopper pumps which convey flow through HE3 to heat the solids passing through the plug flow reactor. Pump data, heat exchanger and boiler design criteria information are summarized in the tables below.

Table 3-9 –Thermophilic Digestion Process Pump Design Criteria

Criteria	Value
Thermophilic Digestion Process Pumps	
Thermophilic recirculation pumps at HE2	
Quantity (Tags)	2 (TB-P-5 and TB-P-6)
Pump Type (Manufacturer)	Centrifugal Chopper Pumps (Vaughan Chopper)
Rated Flow Capacity, gpm	150
Design TDH, ft	20
Plug Flow Heat Exchanger (HE3) pumps	
Quantity (Tags)	2 (TB-P-7 and TB-P-8)
Pump Type (Manufacturer)	Centrifugal Chopper Pumps (Vaughan Chopper)
Rated Flow Capacity, gpm	150
Design TDH, ft	20
Plug Flow Heat Effluent Pumps at HE1	
Quantity (Tags)	2 (TB-P-9 and TB-P-10)
Pump Type (Manufacturer)	Double Disk Pumps (Penn Valley)
Flowmeter	Magnetic (Tag FE-1014)

Table 3-10 - Thermophilic Sludge to Sludge Heat Exchanger (HE1) Design Criteria

Thermophilic Heat Exchanger (HE1)	Summer		Winter	
	Warm Sludge Side	Cool Sludge Side	Warm Sludge Side	Cool Sludge Side
Heat Exchanger Type (manufacturer)	Tube-in-Tube (Olympus Technologies, Inc.)			
Configuration	Sludge to Sludge			
Design Flow, gpm	150			
Heat Transfer Surface Area, ft ²	397			
Number of Tubes	16			
Tube Diameter, in.	5	8	5	8
Inlet Temperature, degrees F	77	140	54	140
Est. Pressure Losses, in. w.c.	<5	<25	<5	<25
Design Heat Transfer, Btu/hr	1,989,000		2,721,000	

Table 3-11 - Thermophilic Sludge to Water Heat Exchanger (HE2) Design Criteria

Thermophilic Heat Exchanger (HE2)	Sludge Side	Water Side
Heat Exchanger Type (manufacturer)	Tube-in-Tube (Olympus Technologies, Inc.)	
Configuration	Sludge to Water	
Heat Transfer Surface Area, ft ²	535	
Number of Tubes	16	
Design Flows, gpm	300	180
Tube Diameter, in.	6	8
Inlet Temperature, degrees F	111	175
Est. Pressure Losses, in. w.c.	<5	<25
Design Heat Transfer, Btu/hr	3,315,000	

Table 3-12 – Plug Flow Reactor Heat Exchanger (HE3) Design Criteria

Plug Flow Reactor Heat Exchanger (HE3)	Sludge Side	Water Side
Heat Exchanger Type (manufacturer)	Tube-in-Tube (Olympus Technologies, Inc.)	
Configuration	Sludge to Water	
Heat Transfer Surface Area, ft ²	535	
Number of Tubes	8	
Design Flows, gpm	150	180
Tube Diameter, in.	4	6
Inlet Temperature, degrees F	131	175
Est. Pressure Losses, in. w.c.	<5	<10
Design Heat Transfer, Btu/hr	698,000	

Table 3-13 –Thermophilic Boiler System Design Criteria

Criteria	Value
Thermophilic Boiler System	
Natural Gas Boiler Rating, BTU/hr.	4,520,000
Rated Inlet Gas Pressure, in. w.c.	31
Input Volume, effective cfh	7,885
Digester Gas Boiler Rating, BTU/hr.	4,520,000

The boilers that feed HE2 and HE3 are designed such that one boiler utilizes natural gas from the local utility and one utilizes digester gas from the thermophilic and mesophilic digesters and the plug flow reactor. The system was designed to use one boiler at a time to heat the thermophilic sludge and the plug flow reactor influent streams. Although the digester gas fed boiler capacity is identical to the natural gas boiler, OWRF staff have observed that the digester gas boiler is not able to meet the system's heat demand, even considering that only HE2 is currently utilized. Even though the boiler does not receive sufficient digester gas to meet its heat demand, the facility continues to flare digester gas at its waste gas flare. OWRF staff have indicated that the boiler will not take the gas without "flaming out" but were not sure of the reason. The boiler system has been modified such that both boilers can be used simultaneously, and natural gas can be used to supplement the biogas supply.

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A thermal switch on the three-way valves on the boiler hot water circulation lines shuts down the boilers when the high water temperature set point is reached regardless of the sludge temperature. The boiler system has no hot water recirculation pumps, so there is no way to circulate hot water when the desired sludge temperature is reached. This results in frequent thermal cycling of, and significant wear to, the boilers. OWRF staff have indicated that the heat exchanger heating loops run as designed, but that a hot water recirculation pump is desired to allow circulation through the boiler system continually to maintain water temperature. This will allow the three-way valves to better control the hot water heating loops.

HE3 is not currently employed to heat sludge but sludge is passing through this unit as it sludge flows cannot be bypassed around the exchanger unit.. The hot water side is currently valved off for the HE3 unit..

The mesophilic digestion process has a sludge heating loop which was originally designed for use with the former aerobic digester tanks which are now repurposed as sludge holding tanks. The boilers associated with this hot water loop were also repurposed to provide heating to the mesophilic digester sludge via a hot water loop. There are two mesophilic boilers, one designed to be powered by digester gas and one designed to be powered by natural gas from the local utility. OWRF staff have indicated that these boilers and the associated hot water pumps have been decommissioned. The mesophilic digestion hot water loop is currently operated as a sludge cooling loop for the mesophilic digester sludge using secondary effluent from Secondary Clarifiers No. 5 and No. 6, which is pumped through the loop by a sump pump at the secondary clarifiers.

3.5.4 Biogas System

The staged digestion process is designed to reduce volatile solids by at least 40%. The volatile solids destruction at the current design is expected to produce as much as 164,000 cf/d of biogas. Most of the biogas production is expected to occur at the thermophilic digester as the highest level of volatile solids destruction occurs across the thermophilic digester compared to the mesophilic digesters.

Biogas collected from the digester is delivered via gas piping to either the boiler or to the flare. A process flow diagram of the biogas collection and conveyance system is provided in Figure 3-2.

Biogas produced as part of the anaerobic digestion process is captured to supplement the heating requirements of the digester hot water heating system. Biogas is designed to be delivered to the hot water heating systems, and any excess production is routed to a flare that burns off excess biogas to prevent its release to the environment. The biogas system is operated by digester gas pressure that is augmented with a booster blower on the inlet side of the digester gas boiler. The digesters are equipped with pressure relief valves rated to blow off excess pressure at 14.5" water column (w.c.).

Recently, the biogas system has been operating at higher than normal pressures. The biogas high line pressures may be linked with issues regarding the pressure relief pop off weights or due to gas line flow restrictions. The biogas lines associated with the mesophilic and thermophilic digestion systems are hydraulically linked, and pressure relief has been observed on both the thermophilic and mesophilic gas piping segments. Manometers on the biogas system indicate pressures of 11 to 13" w.c. Waste biogas pressures were recorded as high as 34 inches w.c. as of October 2021. An investigation of the recorded

pressures indicated that SCADA was performing incorrect pressure measurement. Once scaling corrections were completed waste gas pressures have ranges from 9 to 13 inches w.c. from the Nov. 2021 to April 2022.

The high pressure may, therefore, be indicative of a blockage in the system. OWRF staff also report a pressure drop of approximately 7" w.c. across the flame trap assembly at their flare at 65-72 cfm, which is significantly higher than expected. As discussed in Section 3.5.3, the boiler will not accept sufficient biogas to meet the heat demand. According to its design specifications it is rated for 7,885 effective cubic feet per hour (ECFH) (131 cfm). This indicates that about half the biogas required for heating the boiler is being burned at the waste gas flare.

3.6 Sludge Holding Tanks

Digested sludge discharged from the mesophilic digesters then flows by gravity to Aerobic Digesters No. 1 and No. 2. These are currently not used for post aerobic digestion, but as sludge holding tanks, equalizing flow to the dewatering process (belt filter presses No. 1 and No. 2).

Table 3-14 –Sludge Holding Tank Sizing

Criteria	Value
Number of Basins	2
Basin Shape	Trapezoidal
Basin Maximum Length x Width Dimensions, ft	85 x 85
Maximum Basin Side Water Depth, ft	13.5
Maximum Liquid Volume Per Basin, gal	558,000

3.7 Belt Filter Presses for Dewatering Digested Sludge

Digested solids are fed to the belt filter presses by way of the sludge holding tanks. A centrifugal chopper pump is used to pump digested solids directly from mesophilic digester No. 2 to the dewatering facility. However, OWRF staff report that since this pump was changed from a double disk pump to a centrifugal chopper pump, they have not been able to pump digested solids through the connected piping system directly to the filter press units as the centrifugal pump is not able to vary flow as required for belt press operation. Currently, the digested solids are discharged into the sludge holding tanks and then pumped to the filter presses using two centrifugal pumps. The design criteria for the belt filter press facility equipment are listed in Table 3-15.

The belt filter press system is equipped with a polymer dosing station and 3 dosing pumps. Dewatered solids are conveyed to a hopper for truck loadout.

Table 3-15 –Belt Filter Press System Design Criteria

Criteria	Press 1	Press 2
Press Capacity, lb/hr	3,080	3,080
Press Size, meters	2	2
Press Manufacturer	Ashbrook Simon-Hartley	Ashbrook Simon-Hartley
Press Digested Sludge Feed Range	200 to 300 gpm	200 to 300 gpm
Press Belt Wash Water Flow Rate	100 gpm	100 gpm
Polymer Type	Emulsion	

OWRF Staff note that the belt filter presses function well if feed solids concentrations are maintained between 0.75 to 1.25% total solids. If the feed solids concentration rises above 1.25%, the presses have difficulty dewatering the thicker sludge due to lack of dedicated polymer to sludge mixing facilities. OWRF is planning to install screw press units to augment the belt filter press units and replace them over time. OWRF staff expect the screw press units to be able to process total percent digested sludge solids higher than 1.25%.

The belt filter presses generate pressate and belt wash water streams. These flows are recycled back to the OWRF Primary Clarifiers or the Mixed Flow pump station for treatment. The pressate water is derived from water content removed from the digested solids during the dewatering process.

4 Regulatory Requirements

As defined under the EPA Part 503 Biosolids Rule, classification of biosolids as Class A or Class B indicates an allowable density threshold of pathogens in the biosolids. Another requirement for biosolids to be land applied is that the biosolids must also meet vector attraction requirements. If the biosolids cannot meet the applicable vector attraction and/or pathogen reduction requirements for Class A or Class B biosolids, the biosolids are unclassified and cannot be land applied per the Part 503 Biosolids Rule.

The OWRF digestion process is permitted and designed to produce Class A or Class B Biosolids. The facility currently chooses to produce and test to maintain Class B biosolids production.

The Class A and Class B Biosolids Pathogen Reduction and Vector Attraction requirements are listed in Table 4-1.

Table 4-1 – Requirements for Achieving Class A and Class B Biosolids Pathogen and to Vector Attraction Reduction

Biosolids Produced	Description
Class A Biosolids	• Pathogen Reduction Requirement ○ The density of fecal coliform in the biosolids must be less than 1,000 most probable numbers (MPN) per gram total solids (dry-weight basis). - Or ○ The density of Salmonella sp. Bacteria in the biosolids must be less than 3 MPN per 4 grams of total solids (dry-weight basis). - And ○ Meet one of six stabilization alternatives given in 40 CFR 503. ▪ As stated in the OWRF UPDES Permit, the pathogen reduction requirement is met per 40 CFR 503.32(a)(7)(ii) where sludge is thermally treated maintaining a temperature of at least 50 degrees Celsius (C) (122 degrees Fahrenheit (F)) for at least 5 days. • Vector Attraction Requirement ○ Meet the pollutant and vector attraction reduction requirements set forth in 40 CFR 503. ▪ As stated in the OWRF UPDES biosolids permit, the Vector Attraction Requirement is met per 40 CFR 503.33(b)(1) where the solids are treated through anaerobic digestion for at least 15 days at a temperature of at least 35 degrees C (95 degrees F) with a 38% reduction of volatile solids.

Biosolids Produced	Description
Class B Biosolids	• Pathogen Reduction Requirement ○ Biosolids must be tested to meet fecal coliform limits of less than 2.0×10^6 MPN/g Total Solids, TS (dry-weight basis). - Or ○ Biosolids must be tested to meet fecal coliform limits of less than 2.0×10^6 Colony Forming Units, CFU/g Total Solids, TS (dry-weight basis). ▪ As stated in the OWRF UPDES biosolids permit, the pathogen reduction requirement is met per 40 CFR 503 Appendix B.4.2, by anaerobic digestion, biosolids are treated in the absence of air for a mean cell residence time of at least 15 days at a temperature of 35 to 55 degrees C (95 to 131 degrees F).
	• Vector Attraction Requirement ○ Meet the pollutant and vector attraction reduction requirements set forth in 40 CFR 503. ▪ As stated in the OWRF UPDES biosolids permit, the vector attraction requirement is met per 40 CFR 503.33(b)(1) where the solids are treated through anaerobic digestion for at least 15 days at a temperature of at least 35 degrees C (95 degrees F) with a 38% reduction of volatile solids.

The vector attraction and pathogen reduction requirements for Class B biosolids production carries a time and temperature requirement of at least 15 days at a temperature of 95 degrees F or above. Both the mesophilic and thermophilic digester liquid temperatures are maintained above 95 degrees (per 2020 OWRF HACH WIMs data). SRTs of the thermophilic digester and mesophilic digesters can be combined to meet SRT requirements stated above. OWRF with all digesters in service can currently meet the 15-day SRT requirement with digester temperatures above 95 degrees F and is able to consistently produce Class B biosolids.

It is important to note from the above table that OWRF is currently permitted to achieve Class A Biosolids by providing an extended time and temperature that maintains a temperature of at least 50 degrees C (122 degrees F) in the biosolids over a 5-day SRT. Under current sludge feed flows the thermophilic digester can meet the time requirement by maintaining the thermophilic digester SRT to greater than 5 days.

An examination of the OWRF HACH WIMs thermophilic temperature data for 2020 indicates that the thermophilic digester, under current conditions, can meet the Class A temperature requirement for pathogen. This data indicated the following thermophilic digester temperatures:

- Minimum Day – 114.8 F,
- Maximum Day – 131.3 F and
- Annual average temperature of 127.2 F.

The data does indicate some of the daily temperature data is below 122 F and this validates OWRF staff concerns about reliably meeting Class A Biosolids requirements. However, the data indicates that the system can achieve heating above 122 F and that simple optimization and improvements to the digester heating systems could allow the facility to reliably produce Class A Biosolids under current conditions.

OWRF staff have inquired if Class A or Class B biosolids might be produced with one digester offline. Table 4-2 shows the current and projected digester capacities and achievable SRTs for OWRF based on current data and buildout conditions.

Table 4-2 – OWRF Digester Complex Volumes and Available SRTs at Current and Projected Loads

Description	Thermophilic Digester	Primary Mesophilic Digester	Secondary Mesophilic Digester	All Digesters
Digester Volume, cf	134,000	93,000	93,000	320,000
Digester Volume, gal	1,000,000	696,000	696,000	2,390,000
Average Combined WAS/Primary Sludge and Scum Feed Flow to Digesters, Current Conditions with digester average feed solids at 2%				
Average Sludge Solids Feed Flowrate to Digestion, mgd	0.15			
SRT, days	6.7	4.6	4.6	15.9
Total SRT with Thermophilic Digester Offline, days	0.0	4.6	4.6	9.2
Total SRT with one Mesophilic Digester Offline, days	6.7	0.0	4.6	11.3

Description	Thermophilic Digester	Primary Mesophilic Digester	Secondary Mesophilic Digester	All Digesters
Current, assuming Primary and WAS Sludge Thickening can be achieved to 3% feed solids to OWRF Anaerobic Digestion System				
Average Solids Flow, mgd	0.08			
SRT, days	13.4	9.2	9.2	31.8
Total SRT with Thermophilic Digester Offline, days	0.0	9.2	9.2	18.4
Total SRT with one Mesophilic Digester Offline, days	13.4	0.0	9.2	22.6
Projected without effective solids thickening, thickened solids of 2% only achieved for feed solids sent into OWRF Anaerobic Digestion System				
Average Solids Flow, mgd	0.26			
SRT, days	3.9	2.7	2.7	9.3
Total SRT with Thermophilic Digester Offline, days	0.0	2.7	2.7	5.4
Total SRT with one Mesophilic Digester Offline, days	3.9	0.0	2.7	6.6
Projected, with thickened solids of 3% achieved for feed into OWRF Anaerobic Digestion System.				
Average Solids Flow, mgd	0.11			
SRT, days	9.1	6.3	6.3	21.7
Total SRT with Thermophilic Digester Offline, days	0.0	6.3	6.3	12.6
Total SRT with one Mesophilic Digester Offline, days	9.1	0.0	6.3	15.4

The data presented above indicates, under current facility operation conditions, the Class A and Class B 15-day SRT vector attraction and pathogen reduction requirements for anaerobic digestion can be achieved only with all three digesters online. As the facility nears its buildout capacity, the SRT will diminish until the 15-day SRT cannot be met even with all three digesters online.

If a feed sludge solids concentration could be maintained at 3% solids to the anaerobic digestion system at current OWRF sludge production conditions, then a mesophilic or thermophilic digester could be taken offline while still meeting the 15-day SRT requirement for vector attraction and Class B pathogen reduction. However, at future sludge production rates with 3% feed solids to the anaerobic digestion system, only a mesophilic digester could be taken out of service while still allowing the system to meet

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the 15-day SRT requirements for Class B Biosolid vector attraction and pathogen reduction requirements.

At buildout conditions, to allow the thermophilic digester to be taken out of service while meeting the 15-day SRT requirement for Class B vector attraction and pathogen reduction (Class B), an additional digester is needed or feed solids into the OWRF digesters would need to be increased to over 3.5%.

The OWRF's UPDES discharge permit valid from April 19, 2021, thru April 18, 2026, indicates that Orem is required to test for pathogens in its biosolids at least 4 times a year. In practice, Orem conducts its pathogen sampling for every dewatered biosolids batch applied to the OWRF drying beds. Therefore, pathogen sampling occurs far more frequently than the required 4 times per year. A summary of the fecal coliform testing conducted between 2015 and 2019 on OWRF produced biosolids follow in Table 4-3.

Table 4-3 – OWRF UPDES Permit Pathogen Monitoring Results

PATHOGEN MONITORING DATA (Anaerobic Cake)

The Permittee must sample for pathogen at least 4 times per year. They sample once per batch/drying bed. Resulting in more samples than the minimum required. All biosolids land applied have met the Class B pathogen standards through anaerobic digestion.

Orem Fecal Coliform Monitoring Data

Fecal Coliform	
Year	Geometric Mean
2019	151
2018	609
2017	64
2016	112
2015	62

Based on the fecal coliform results reported in the permit and shown above, the OWRF dewatered biosolids easily achieve Class B pathogen reduction requirements and achieves Class A pathogen reduction for fecal coliform.

For Class A Biosolids Pathogen Reduction requirements time and temperature requirements are used instead of SRT to achieve pathogen reduction requirements. The OWRF is currently permitted to achieve Class A time and temperature pathogen reduction that can be accomplished using its Thermophilic Digester if digester sludge temperature is above 122 F and a 5-day SRT is provided. However as discussed above, if sludge is not thickened to 3% as facility flows increase, the 5-day SRT Class A requirement for the thermophilic digester will not be achieved and Class A biosolids criteria would not be achieved.

In addition to the pathogen and vector attraction requirements, OWRF biosolids must also achieve pollutant regulations for metals to allow for land application. The following figure presents Table 2-1,

from the “A Plain English Guide to the EPA Part 503 Biosolids Rule” which defines Ceiling concentrations for heavy metal pollutants depending on biosolids use:

**TABLE 2-1
Pollutant Limits**

Pollutant	Ceiling Concentration Limits for All Biosolids Applied to Land (milligrams per kilogram)^a	Pollutant Concentration Limits for EQ and PC Biosolids (milligrams per kilogram)^a	Cumulative Pollutant Loading Rate Limits for CPLR Biosolids (kilograms per hectare)	Annual Pollutant Loading Rate Limits for APLR Biosolids (kilograms per hectare per 365-day period)
Arsenic	75	41	41	2.0
Cadmium	85	39	39	1.9
Chromium	3,000	1,200	3,000	150
Copper	4,300	1,500	1,500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum ^b	75	—	—	—
Nickel	420	420	420	21
Selenium	100	36	100	5.0
Zinc	7,500	2,800	2,800	140
Applies to:	All biosolids that are land applied	Bulk biosolids and bagged biosolids ^c	Bulk biosolids	Bagged biosolids ^c
From Part 503	Table 1, Section 503.13	Table 3, Section 503.13	Table 2, Section 503.13	Table 4, Section 503.13

^a Dry-weight basis

^b As a result of the February 25, 1994, Amendment to the rule, the limits for molybdenum were deleted from the Part 503 rule pending EPA reconsideration.

^c Bagged biosolids are sold or given away in a bag or other container.

OWRF biosolids are land applied in bulk which requires the biosolids to achieve limits for the following EPA 503 biosolids categories:

- Exceptional Quality (EQ) biosolids metals limits if producing biosolids characterized with Class A pathogen reduction and with specific low metals limit pollutant concentration limits.
- Pollutant Concentration (PC) biosolids that are characterized with Class B pathogen reduction and with metals limits like EQ biosolids.

The biosolids that exceed metals pollutant concentrations for EQ biosolids and are sold or given away for personal land application use must meet annual pollutant loading rate (ALPR) metals levels.

The testing results performed in 2019 by Orem indicate that the biosolids produced by OWRF can easily achieve the EQ and PC requirements for biosolids as required in the Orem UPDES permit with regards to metals:

METALS MONITORING DATA

Orem was required to sample for metals at least four times in 2019. Orem sampled the Class B biosolids 9 times. All biosolids land applied in 2019 met *Table 3 of 40 CFR 503.13*, therefore Orem biosolids qualify as EQ with regards to metals. The monitoring data is below.

Orem Metals Monitoring Data 2019

Orem Monitoring Data, 2011 - 2019			
Parameter	Table 3, mg/kg (Exceptional Quality)	Average, mg/kg	Maximum, mg/kg
Arsenic	41.0	8.2	19.8
Cadmium	39.0	2.9	6.72
Copper	1,500.0	505	773

City of Orem FSSOB
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Page 11

Lead	300.0	28	140
Mercury	17.0	1.5	4.27
Molybdenum	75.0	16	26.4
Nickel	400.0	52	158
Selenium	36.0	14.4	59.3
Zinc	2,800.0	777	1570

OWRF is required to test biosolids that are land applied for metals at least 4 times a year. For 2019, OWRF staff conducted a total of 9 metals tests on its land applied biosolids as indicated in the permit information provided above. The metals test results meet applicable regulations.

5 Improvement Alternatives for Biosolids Management and Processing

A summary of key OWRF specific bulk quantity land application requirements with Class A or Class B Biosolids include:

- For Class A Biosolids, a more stringent fecal coliform reduction is required but chain of custody reporting is less stringent, compared to Class B Biosolids especially related to soil testing requirements at the fields where solids are being applied.
- For Class B biosolids, land application sites are located near the OWRF and are willing and certified to accept Class B biosolids. In addition, field soil testing at the application sites is required as part of applying Class B biosolids. This requirement is not applicable to application of Class A biosolids.

Currently, OWRF has an arrangement to haul its biosolids to nearby farms who currently accept the OWRF biosolids for free. The farmers apply the biosolids as a crop fertilizer (crops grown include grass hay, alfalfa, and silage corn). OWRF provides the labor and trucking equipment to haul Class B biosolids to the farm sites and provides the associated soil monitoring efforts on behalf of the farmers to allow the sites to receive Class B biosolids. OWRF biosolids consistently meet exceptional quality biosolids metal limits and Class A or Class B pathogen reduction and vector attraction requirements for land application.

The facility currently produces Class B biosolids on a consistent basis with all digesters in operation. The facility cannot reliably produce Class A biosolids with all digesters online or Class B biosolids if one digester is offline. Since future regulations or biosolids users may be required to employ Class A biosolids only, OWRF staff want to explore options to achieve Class A biosolids by adding digester volume or other potential alternatives.

The following improvements alternatives have been developed to maximize the use of existing OWRF process technologies and tankage while meeting Class A or B biosolids while providing sufficient system redundancy to take any digester offline while meeting EPA biosolids regulatory requirements. In addition, select improvement alternatives are developed below to control ammonia and phosphorous return loads to the liquid stream process. The new facility alternatives are also developed below to increase or provide new facilities to improve operations and maintenance and address current and future regulations.

The goals and corresponding alternatives for OWRF biosolids management include:

Objective	Proposed Improvements
1- Provide Improvements to Existing Anaerobic Digestion System to Reliably Achieve Class A or B Biosolids.	Provide improvements to existing digester related facilities including pumping, boilers, and gas collection. Provide thickening improvements for DAF and allow PS/WAS cothickening at DAF. Construct new digester volume to provide redundancy and facilitate digester maintenance while meeting EPA SRT requirements.
2- Address future contaminant of concern regulations and expand biosolids use	Construct new based pyrolysis drying facility to address future contaminant of concern regulations and expand biosolids use options while reducing wet tons of biosolids produced
3- Control nitrogen and phosphorous loading from return stream flows to the liquid stream process	Construct new patented sequestration system to remove phosphorous from dewatering return flows back into the liquid stream process
4- Resource recovery	Construct facilities to produce commercial grade biofuel for city fleet vehicles to provide resource recovery capability to the OWRF anaerobic digestion system.

5.1 Alternative 1 - Provide Improvements to Existing Anaerobic Digestion System to Reliably Achieve Class A or B Biosolids

This alternative will summarize the improvements to the OWRF current biosolids facilities to allow the OWRF to continue to bulk quantity land apply OWRF Class A or B biosolids to local agricultural sites using existing facilities.

A 2016 study was conducted to identify the cause of and recommend solutions for problems identified in the OWRF's thermophilic digestion system. These problems included:

1. Higher than expected maintenance demand at the digester gas boiler system.
2. Impaired ability to meet the demands of the thermophilic and mesophilic digestion systems with the biogas system resulting in high natural gas expenses.
3. Corrosion and scaling within the biogas system, due to siloxane buildup.
4. Inadequate boiler supply/return water temperatures.

5. Transfer of gas from the mesophilic digester to the flare and biogas boiler are impaired causing gas to blow off rather than feed the boiler or flare.

Digester gas was sampled and analyzed revealing a higher-than-expected hydrogen sulfide (H₂S) concentrations in the OWRF biogas. Siloxane levels were in the expected range. Potential causes of the poor biogas quality were moisture in the biogas, excessive hydraulic load, and ratio of primary solids to secondary solids. To address the moisture content of the biogas, OWRF staff constructed a make-shift system to drop condensation out of the biogas.

Recommendations of the 2016 study:

1. Thicken primary sludge and WAS to reduce hydraulic loading and improve the solids feed rate.
2. Discontinue alum dosing in favor of ferric chloride or ferrous chloride to reduce H₂S in biogas and promote methane generation or install a biological water scrubber to scrub H₂S. OWRF staff have noted that use of iron metal-based chemicals availability is extremely limited in supply at this time.
3. Calibrate temperature and pressure gauges to verify accurate readings. Repair or replace, as necessary.
4. Add temperature transmitters to the heating loops on the boiler systems to allow tracking and preemptively alert staff of maintenance issues.
5. Maintain boiler supply temperatures at 160-180 degrees F and return water above 140 degrees F preventing condensation, corrosion, and thermal cycling: add a recirculation pump to recirculate a portion of the hot water supply to the cool water return to maintain return temperatures and improve overall heating capabilities.
6. Modify boiler system to operate the biogas boiler as the lead and the natural gas boiler as the lag to maximize biogas usage, and allow supplemental natural gas as required.

The OWRF digester solids data also indicates that the sludge volatile suspended solids (VSS) feed to the anaerobic digester process is only in the range of 0.8 to 1.8% solids. This is attributed to the sludge pumping challenges. OWRF staff report that it is difficult to process feed sludge total solids concentrations above 2% into the OWRF Anaerobic Digestion System with the current sludge pumping equipment.

Municipal anaerobic digestion experts have indicated that low volatile solids loading rates into digesters can result in designs that are troublesome to operate and require costly digester volumes to accommodate. Speece (1988) conducted a survey of 30 United States digester installations and the survey noted (in its opinion) a low percent feed sludge TSS into the digesters at 4.7% plus or minus 1.6% with a 70% VSS content. The average % VSS within the digesters surveyed was only a dilute 1.6%.

The Speece survey noted that dilute sludge feed causes low volatile solids loading within the digester and this can result in the following potential adverse impacts to digester operation including:

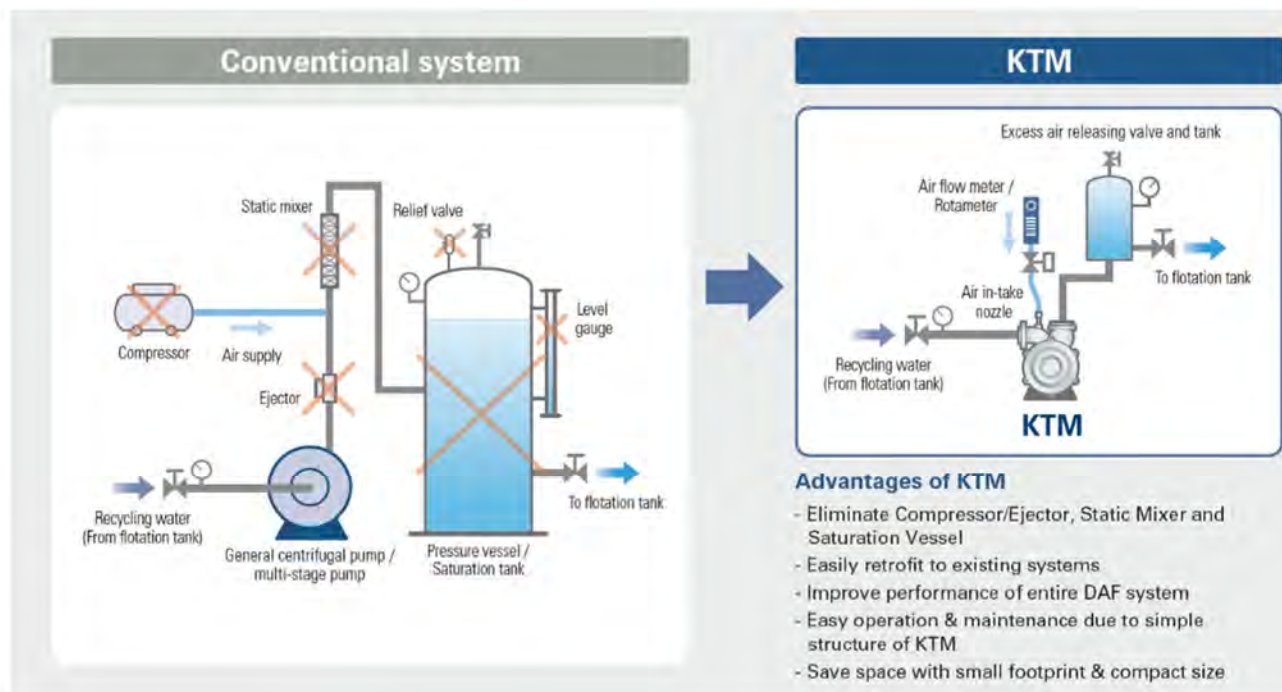
- Reduced solids retention times
- Reduced volatile solids destruction performance
- Reduced methane production

- Reduced alkalinity
- Increase volumes of digested biosolids and supernatant
- Increased heating requirements
- Need for increased dewatering capacity
- Increase hauling costs for liquid biosolids

However, it is noted that care must be taken when thickening WAS to above 4% total solids content, as ammonia toxicity from WAS sludge anaerobic digestion may become of concern within the digesters.

5.1.1 Thickening, Conveyance and Heating Improvements

1. This improvement alternative includes the following recommendations: Evaluation and replacement of existing primary sludge pumps to facilitate primary sludge gravity thickening (up to the 2 to 3% total solids range).
2. Improvements to the existing WAS DAF unit by installing newer, improved air saturation pumps. An example manufacturer and model of such pumps is the Nikuni KTM micro bubble pump. Employment of such pumps would remove the need to maintain air saturation tanks and air compressor equipment. In addition, the employment of improved air saturation pumps would allow higher thickened WAS solids at 3% and increased load capacity of the DAF unit. Also, the improved DAF unit could be employed to cothicken WAS and PS.



3. Evaluation and replacement of the existing centrifugal chopper style digester sludge feed and recirculation pumps with sludge chopper or screw centrifugal pumps with or without inline grinder units. Chopper style pumps include Hayward Gordon CHOPX pumps and Wemco screw

centrifugal pumps as manufactured by Trillium Flow Technologies. Another emerging pumping technology for the municipal market to better pump thickened sludges is the horizontal slurry pump line manufactured by the Eddy Pump Corporation that can be supplied with chopper or self-priming adders.

4. Evaluation and improvements to existing digester mixing systems to better process thickened sludge feed. Mixing improvements could include augmenting or replacing thermophilic and mesophilic digester existing mixing systems with linear motion mixing systems.
5. Evaluation and improvements to the existing boiler systems. Current boilers have flame out issues and gas booster systems may need to be upgraded to facilitate more reliable boiler operation. Boiler upgrades would also include the installation of recirculation pumps to prevent on/off cycling operation for the boilers and provide ability for the Thermophilic digester to consistently maintain sludge temperatures above 122 F.
6. Evaluation of and improvements to existing heat exchangers to ensure proper sludge heating to design levels for Thermophilic vs Mesophilic operation. As an option direct steam injection system (as manufactured by Hydro-Thermal or Prosonix) compared to hot water boilers could be considered to remove the need for heat exchangers and hot water loops and significantly reduce heat exchanger equipment footprint.

One benefit of operating the digesters to Produce Class A biosolids is the reporting requirements for sludge application under the Class B requirements would be removed (e.g., soil testing and logging of sludge applications to specific areas).

5.1.2 Construct New Digester Volume

One alternative is to add one hybrid digester similar in size to the existing thermophilic digester. The new hybrid digester will be configured such that it could operate either as a mesophilic or thermophilic digester. The construction of a new digester would facilitate the ability to take any digester off-line while still meeting the EPA 15-day SRT requirements for current and future conditions. Alternatively, OWRF could construct two digesters - one dedicated mesophilic digester and a second dedicated thermophilic digester. This option will have the highest level of reliability and flexibility.

5.2 Alternative 2 - Construct Pyrolysis Based Sludge Drying System

This alternative would be considered to allow OWRF to provide biosolids that could achieve removals of future contaminants of concern from the biosolids if biosolids regulation changes in the future and reliably produce Class A biosolids without the need to employ the thermophilic digester at elevated temperatures above 122 degrees F. Numerous districts and cities such as South Valley, UT, Redding, CA and Edmonds, WA have chosen pyrolysis based drying systems over other drying systems due to the ability of pyrolysis to provide self-sustaining heating and the ability to remove contaminants of future concern due to very high heat operation. The biosolids produced from this alternative would expand biosolids use opportunities beyond just agricultural applications as well and significantly reduce volume of biosolids material due to higher solids content product produced.

5.3 Alternative 3 – Control of Phosphorous and Nitrogen Return Stream Loadings

5.3.1 Improvements to Existing Solids Storage Facilities

These improvements will include updated controls, mixing and instrumentation improvements, and phased aeration of the existing sludge storage tanks to control nitrogen and phosphorous levels released back to the liquid stream process.

5.3.2 Construct New Patented Sequestration System to Reduce Phosphorous in Dewatering Return Flows

This improvement consists of installing a patented process such as Ovivo's Elo-Vac-P system via chemical addition using magnesium chloride to sequester phosphorous from the OWRF sludge to reduce the return load of phosphorous in the filter-belt-press pressate back to the liquid stream process. The OWRF staff is planning to pilot the Ovivo Elo-Vac-P system in the near future.

5.4 Alternative 4 - Construct Facilities to Produce Commercial Grade Biofuel for City Fleet Vehicles.

For this alternative biogas cleaning and clean gas storage facilities would be constructed. The biogas cleaning facilities would concentrate methane and remove contaminants such as VOCs, carbon dioxide, moisture, siloxanes, and hydrogen sulfide from the biogas to produce cleaned renewable natural gas (RNG) product with 95% methane content. Clean RNG storage facilities would also be constructed to store and pressurize the RNG to allow vehicle refueling. The stored RNG would be used to fuel city fleet vehicles or other City related service vehicles such as garbage trucks and buses. The Cities of Tacoma, WA (population 215,000) and Longmont, CO (population 100,000 with 13 mgd design WWTP generating 140,000 cu ft per day of digester gas) have employed such systems to replace their diesel fueled service vehicles with renewable natural gas RNG fueled vehicles.

APPENDIX E. **Condition Assessment Technical Memorandum**



OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
CONDITION ASSESSMENT MEMORANDUM

OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
CONDITION ASSESSMENT MEMORANDUM

Date: December 14, 2022

Prepared By: Jayesh Charthal

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Table of Contents

Executive Summary.....	4
1. Evaluation of Existing Equipment and Structures	5
1.1. Standard Useful Life	5
1.2. Adjustment for Age.....	6
1.3. Adjustment for Use.....	6
1.4. Base Remaining Useful Life.....	6
1.5. Condition Assessment.....	7
1.6. Performance Assessment	8
1.7. Risk of Failure	8
2. Criticality Assessment	8
3. Risk and Criticality Matrix	10
4. Summary of Results By Area.....	11
4.1. Condition and Performance Assessment Results	11
4.1.1. General Assessment of All Structures and Buildings at OWRF.....	11
4.1.2. General Assessment of Programmable Logic Controllers (PLCs) at OWRF	11
4.1.3. General Assessment of NFPA 820 requirements.....	11
4.1.4. Headworks Building	12
4.1.5. Aerated Grit and Aerated Grit Blower Building.....	14
4.1.6. Primary Clarifiers.....	15
4.1.7. Primary Sludge Pump Building.....	16
4.1.8. Mixed Flow Pump Station and Screw Pump station.....	19



4.1.9. Bioreactors	21
4.1.10. Bioreactor Blower Building	26
4.1.11. Secondary Clarifiers	27
4.1.12. RAS and WAS Pump Building, and Generator Building	29
4.1.13. UV Building.....	31
4.1.14. Chlorine Building.....	32
4.1.15. Dissolved Air Flootation (DAF)	33
4.1.16. Thermophilic Digester.....	35
4.1.17. Mesophilic Digesters.....	37
4.1.18. Aerobic Digesters	40
4.1.19. Biosolids Building	43
4.1.20. Flare Stack	46
4.1.21. Drying Beds	48
4.1.22. Miscellaneous Buildings.....	49
4.2. Replacement Priority By Criticality and Risk.....	51
4.2.1. Interpretation of Results.....	51
4.2.2. High Criticality and High Risk of Failure Assets.....	52
4.2.3. High Priority Replacements or Upgrades.....	56
4.2.4. Schedule Asset Replacements or Upgrades	61

Table of Figures

Figure 1 – Process for Estimating the Risk of Failure.....	5
Figure 2 – Relation between Age and Predicted Remaining Life.....	6
Figure 3 – Relation Between Condition Score and Remaining Life	8
Figure 4 – Spalling of concrete at the beam, cracks on walls, discoloration on walls due to seepage of water through cracks at Headworks Building.....	13
Figure 5 – Condition of Headworks Building wall near Aerated Grit Channel	13
Figure 6 – Cracks on Headworks Building near overhead door.....	14
Figure 7 - Worn out and leaking air piping at Aerated Grit	15
Figure 8 - Electrical disconnect at the Primary Clarifiers.....	16
Figure 9 – Cracks inside the Primary Sludge Pump Building.....	17
Figure 10 - Cracks inside the Primary Sludge Pump Building	18
Figure 11 - VFD panel, electrical disconnect at Primary Sludge Pump Building.....	19

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Figure 12 - Mixed Flow Pump Station.....	20
Figure 13 – Screw Pump Station	21
Figure 14 – Bioreactor No. 2 Cracks.....	22
Figure 15 – Spalling of concrete and cracks on Bioreactor No. 2 walls.....	23
Figure 16 – Sludge on pavement near Bioreactor No.1	24
Figure 17 – Surface aerator in Bioreactor No. 2	25
Figure 18 - Generator batteries at Bioreactor Blower Building.....	27
Figure 19 – Clarifier No. 5 Center Well	29
Figure 20 – Generator showing the exhaust system	30
Figure 21 – UV Channel influent and effluent gates with actuators.	32
Figure 22 – DAF Basin	34
Figure 23 – Electrical disconnects and recycle pumps at the DAF	35
Figure 24 - Atmospheric monitors	36
Figure 25 – Odor Control unit at Thermophilic Digester	37
Figure 26 – Floating cover and mixer on mesophilic digester	39
Figure 27 - Cracks on mesophilic digester tank	40
Figure 28 – Grinder pumps at Aerobic Digester Building	42
Figure 29 - Blower control panel at Aerobic Digester Building	43
Figure 30 – Belt Press and cover at Biosolids Building	45
Figure 31 - Belt Press control panel	46
Figure 32 – Flare stack near Thermophilic Digester	48
Figure 33 – Deterioration at Maintenance Shop Building.....	50
Figure 34 - Pumps at Impure pump Building	51

List of Tables

Table 1-1	Condition Assessment Scoring Definitions	7
Table 2-1	Criticality Rating Definitions	9
Table 3-1	Risk of Failure and Criticality Matrix	11
Table 4-1	High Criticality and High-Risk Assets.....	52
Table 4-2	High Priority Replacement and Upgrades.....	56
Table 4-3	Assets to be Scheduled for Replacement or Upgrade.....	61

Executive Summary

A Risk Assessment of the Orem Water Reclamation Facility (OWRF) was conducted. The Risk Assessment approach included asset identification using existing design and construction documents, a systematic asset evaluation with facility operators, and a compilation of findings into this technical memorandum. The systematic risk evaluation was based on the risk of failure and criticality. The industry recognized remaining useful life estimation using asset age, use, condition, and performance is a surrogate for risk of failure. Criticality is estimated by rating the safety, permit reliability, redundancy, flexibility, and operational impacts of each asset in accordance with a quantitatively defined scoring system.

Evaluation of Existing Equipment and Structures

A performance and general condition assessment was conducted for the existing treatment process related equipment and structures at the Orem Water Reclamation Facility (OWRF). The assessment is intended for use in developing a comprehensive plan for current and future upgrade and expansion projects necessary to maintain the OWRF’s current level of service, meet anticipated future regulations, and future capacity requirements. An analysis was conducted to determine the risk of failure of all process related equipment and structures. This analysis utilized a systematic process for evaluating each component based on its anticipated useful life, age, use and condition as outlined in Figure 1.

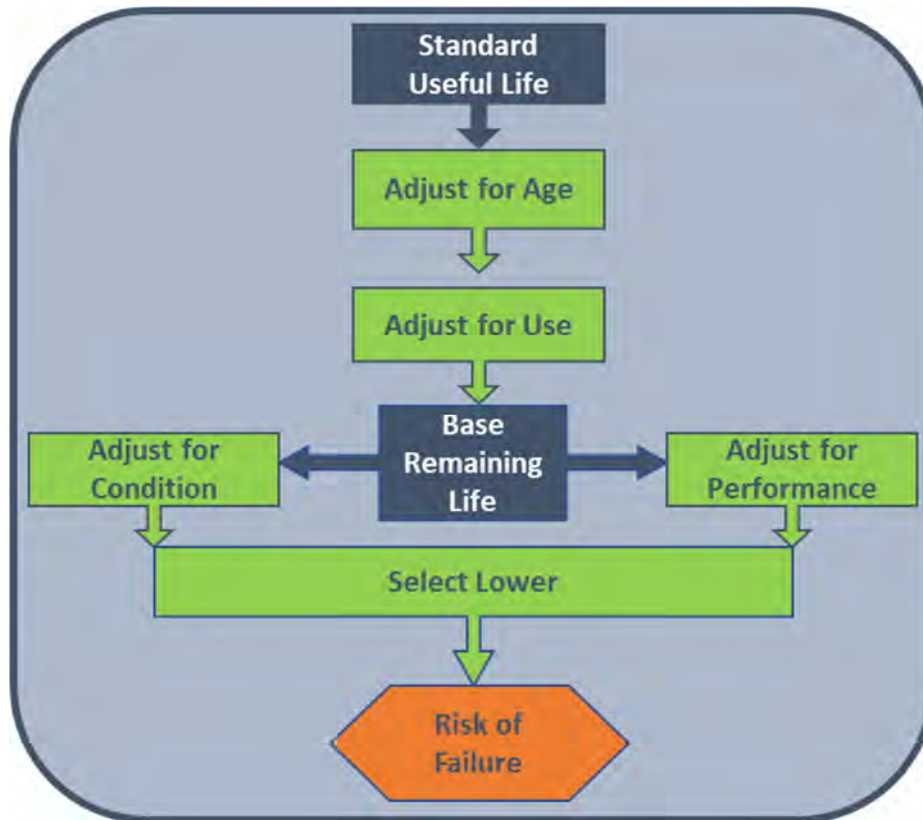


Figure 1 – Process for Estimating the Risk of Failure

OWRF staff reviewed equipment records and performed the inspection and evaluation of the equipment and structures. Information gathered from this effort was used to populate a spreadsheet-based evaluation tool that calculates the estimated likelihood of failure of each asset. An electronic copy of the spreadsheet utilized in this study will be submitted with the memorandum. The process used to perform this evaluation is described below.

1.1. Standard Useful Life

The standard useful life of the equipment and structures was determined based on industry standard expectations for the life of equipment and structures, with some modifications made based on the experience of those conducting the evaluation. For equipment, the standard useful life utilized ranged from 10 to 20 years dependent on the type and complexity of the equipment. For pipe, valves and appurtenances, the standard useful life ranges from 20 to 40 years. For structures, the standard useful

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life ranges from 40 to 50 years based on the type of construction and environment. For electrical equipment and components, electrical hardware and software, instruments the standard useful life ranges from 10 to 20 years. There are few exceptions where standard useful life does not fall in the range mentioned above.

1.2. Adjustment for Age

The age of the structures and equipment was determined based on records for construction and equipment installation. The age of the equipment or structure was deducted from the standard useful life to determine the expected relative risk of failure based on age. In many cases the age exceeded the standard anticipated useful life. In these cases, the expected useful life of the equipment was increased using the relation shown in Figure 2 to account for the years of service achieved beyond the standard useful life.

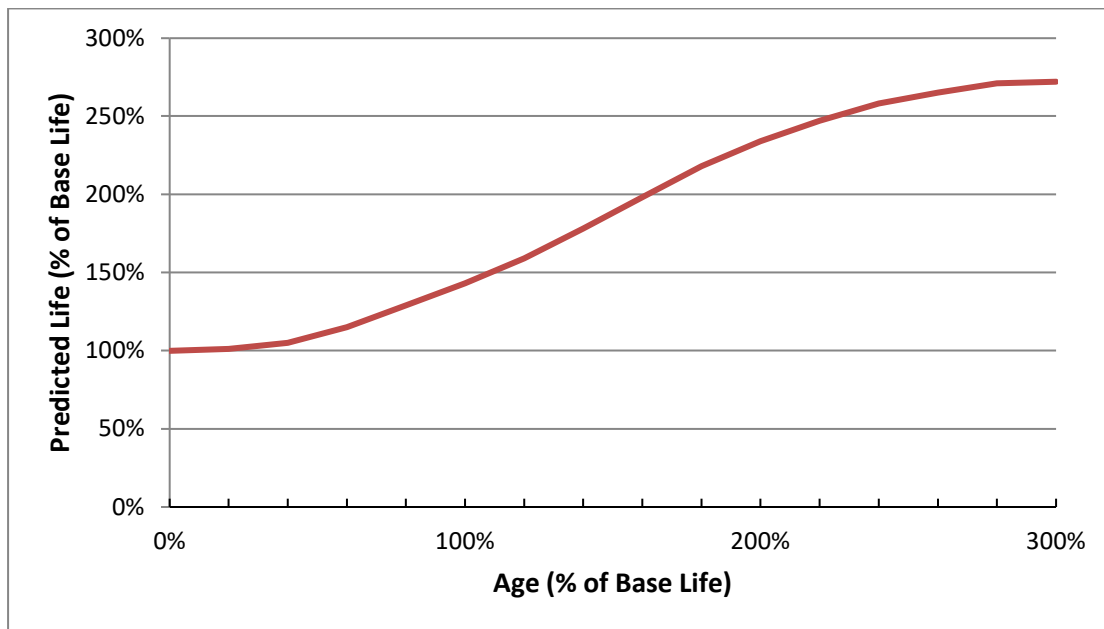


Figure 2 – Relation between Age and Predicted Remaining Life

1.3. Adjustment for Use

The use of the equipment is intended to account for the hours of operation that is typical for each piece of equipment or structure. Equipment usage was entered into the spreadsheet as a percentage of time used in a typical day based on 24-hour usage being 100%.

1.4. Base Remaining Useful Life

The base remaining useful life documents the expected relative risk of failure after the adjustment for age and use. This number represents the number of years that the equipment or structure would be expected to continue to provide service without consideration for its current condition or performance.

1.5. Condition Assessment

The condition of equipment was assessed by facility operators and maintenance staff. Definitions used in the rating are presented in Table 0-1.

Table 0-1 Condition Assessment Scoring Definitions

Score	Condition	Wear	Renewal Requirement	Annual Corrective Maintenance Expense
1	Like New	Little	No Action Required	< 5%
2	Very Good	Normal – Light	Minor Renewal Required	5% to 10%
3	Satisfactory	Normal - Heavy	Moderate Renewal Required	10% to 20%
4	Poor	Abnormal	Scheduled Replacement Required	20% to 40%
5	Very Poor	Failure Imminent	Immediate Replacement Required	> 40%

Condition and wear were assessed based on visual inspection of the equipment by OWRF staff. Renewal and annual maintenance expenses were assessed based on records for equipment maintenance and replacement. The overall condition assessment score was determined based on the highest rating assigned in the categories listed. For example, if a piece of equipment was found to be in satisfactory condition (condition rating = 3), exhibit normal/light wear (wear rating = 2), requires minor renewal (renewal rating = 2), but its annual corrective maintenance cost incurred is greater than 40% of the equipment capital cost (maintenance rating = 5), the equipment was assigned a score of 5. This scoring method was found to be more representative of the true condition of the equipment than alternate methods such as averaging the scores, since some equipment showed little wear and appeared to be in good condition, but the cost to keep it in good operational condition was excessive, while other equipment showed significant wear and degradation, but very little had been spent on maintenance or renewal.

Based on the scores assigned through the condition assessment, a remaining life multiplier was assigned for each component being analyzed based on the relationship depicted in Figure 3.

The multiplier is used within the remaining life assessment to adjust the base remaining useful life to account for equipment condition. Components that are new and/or in good condition receive a multiplier at or near one, resulting in minimal adjustment to the base remaining useful life. Components that have failed or are in poor condition are assigned a multiplier near zero, resulting in a significant reduction in their expected useful life.

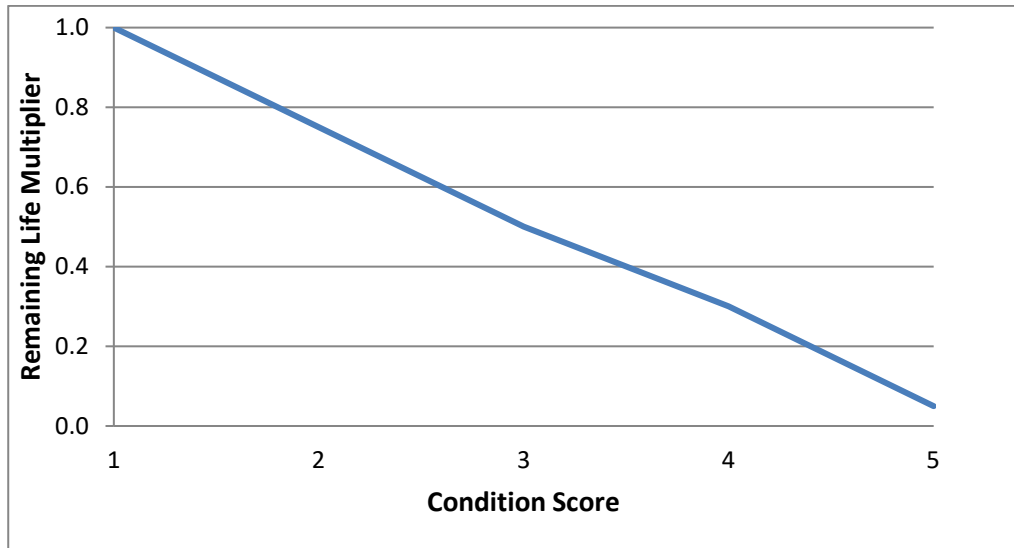


Figure 3 – Relation Between Condition Score and Remaining Life

1.6. Performance Assessment

In addition to the assessment of condition, the performance of the equipment and structures was evaluated. This evaluation is intended to account for equipment that is in good condition, but that does not perform its intended service to the satisfaction of OWRF staff or does not meet capacity or other performance requirements. The evaluation of performance was conducted based on information from facility managers and operators. The intent of this evaluation was to identify equipment that does not perform useful service to the operation of the facility or is anticipated to be under sized in the near future. As this evaluation is subjective, numerical scores or multipliers were not utilized. Adjustments to the useful life were made manually based on the assessment by Water Works Engineers and OWRF staff to change the risk of failure and designate asset as replace asset immediately or prioritize the asset replacement or schedule the asset replacement as needed. Equipment or structures that currently do not meet their intended service requirements were assigned a remaining useful life of zero. This adjustment is used to identify equipment or structures that are no longer useful to the performance of the facility and should be removed or replaced. The base useful remaining life was not adjusted for equipment or structures that were identified to have moderate to small performance issues.

1.7. Risk of Failure

The risk of failure calculated for each asset is a surrogate for the adjusted base remaining useful life based on the condition and performance assessments. It is not a prediction of when equipment will fail. The units of risk of failure are in years and the ranges used to classify priority assets are adjustable according to the City’s preference.

2. Criticality Assessment

In addition to the determination of relative risk of failure, the project team also performed a criticality assessment for all equipment and structures. This assessment was intended to identify the nature and severity of impacts that an equipment or structural failure would have on the operation of the OWRF.

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Each piece of equipment and structure was assigned a rating based on the effect a failure would have in the following five areas:

- Safety – Assessment of the risk of harm to operations staff that would be created by a failure.
- Permit Compliance/Process Reliability – Assessment of the impact that a failure would have on the facility's ability to meet its permit requirements.
- Redundancy – Assessment of the level of redundancy that is currently in place based on the treatment capacity the facility would maintain in a failure event.
- Flexibility – Impact that a failure would have on the facility's ability to react to changes in operating conditions, flow and/or load.
- Operational (Operation and Maintenance (O&M)) Impacts – Assessment of the cost in operator time and/or money that will be incurred due to a failure.

Water Works Engineers worked with OWRP staff to assign a rating from 1 to 5 in each of these categories. Ratings were assigned according to the following definitions:

Table 2-1 Criticality Rating Definitions

Safety	
Rating	Definition
1	No Impact
2	Moderate Potential for Minor Injury
3	Create Hazardous/Unhealthy Work Environment
4	Moderate Potential for Severe Injury
5	High Potential for Severe Injury
Permit Compliance/Process Reliability	
Rating	Definition
1	No Impact
2	Minor Process Performance Interruptions
3	Decreased Process Performance/Low Potential for Permit Violation
4	Moderate Potential for Permit Violation
5	High Potential for Process Failure/Permit Violation
Redundancy	
Rating	Definition
1	Fully Redundant/No Loss in Capacity
2	Minor and/or Short Term Loss in Capacity
3	Partial Redundancy/Maintain 65% or More Capacity
4	Partial Redundancy/Maintain 50% Capacity
5	No Redundancy
Flexibility	
Rating	Definition
1	No Impact
2	Moderate Operational Limitations Requiring Minimal Effort to Address

3	Significant Operational Limitations Requiring Moderate Effort to Address
4	Significant Operational Limitations Requiring Substantial Effort to Address
5	Inability to Respond to Changing Conditions
Operational (O&M) Impacts	
Rating	Definition
1	No Impact
2	Minimal Effort/Time/Cost
3	Moderate Effort/Time/Cost
4	Significant Effort/Time/Cost
5	Substantial Effort/Time/Cost

The criticality of the equipment and structures is determined by taking the average of the scores in the five categories. A category weighting can be used to place more emphasis on categories that are more important, but for this analysis OWRF staff decided to maintain an equal weight for all categories. The resulting criticality rating ranges from 1 to 5 where 1 indicates low criticality and 5 indicated extremely critical.

3. Risk and Criticality Matrix

As discussed above, the risk of failure is represented by the anticipated remaining useful developed based on age, use, condition and performance.

- The assets at the facility that are both high criticality and have high risk of failure must be replaced or upgraded immediately. These assets have been categorized as having both high criticality (scores between 4 and 5) and high risk of failure (estimated relative risk of failure of less than negative 10 years).
- Assets that have medium criticality (scores of 3) and have high risk of failure or have medium risk of failure (between negative 10 and 0 years of relative risk of failure) and high criticality should have scheduled replacement or upgrades and be flagged as high priority.
- Assets that have medium criticality (scores of 3) and have medium risk of failure or have high risk of failure and low criticality (score between 1 and 2) should be flagged as scheduled replacement or upgrades to be considered after high priority replacement. OWRF staff shall monitor these assets proactively. If risk of failure or criticality based on continued monitoring changes then these assets shall be replaced accordingly.
- All other equipment that has low risk of failure (more than 0 years of remaining life) or low criticality (scores between 1 and 2) should be scheduled for replacement or upgrades as applicable. The risk and criticality matrix is shown in Table 3-1.

Table 3-1 Risk of Failure and Criticality Matrix

		CRITICALITY		
		HIGH (4 - 5)	MEDIUM (3)	Low (1 – 2)
RISK OF FAILURE	HIGH <-10 YEARS	Replace/Upgrade Immediately	Schedule Upgrade/Replacement High Priority	Monitor or Schedule Upgrade/Replacement
	MEDIUM -10 – 0 YEARS	Schedule Upgrade/Replacement High Priority	Monitor or Schedule Upgrade/Replacement	Plan Upgrade/Replacement
	LOW >0 YEARS	Plan Upgrade/Replacement	Plan Upgrade/Replacement	Plan Upgrade/Replacement

4. Summary of Results By Area

An electronic copy of the spreadsheet that documents this evaluation will be submitted with the memorandum. All scoring and rating determinations made can be reviewed and adjusted in the spreadsheet to maintain an up-to-date assessment of the condition and criticality of OWRF equipment and structures.

4.1. Condition and Performance Assessment Results

OWRF staff identified several treatment units and processes that have known condition or performance issues or that are nearing the end of their expected useful life and may soon present performance issues.

4.1.1. General Assessment of All Structures and Buildings at OWRF

OWRF staff has mentioned that due to age, many facilities and structures do not meet current structural and seismic code requirements. In the event of an earthquake, any structure or building may fail and may impede the facility operations. The facility is located approximately 4 miles from the Wasatch fault line, which may expose OWRF to earthquakes and tremors of considerable strength. It is, therefore, recommended that a detailed structural evaluation be considered and suggested structural improvements be implemented. All new construction is expected to conform to the latest building code requirements.

4.1.2. General Assessment of Programmable Logic Controllers (PLCs) at OWRF

OWRF staff has indicated that all the installed PLCs are at the end of their life and more than 12 years old. An industry standard for the expected life of a PLC is 5 years. OWRF staff experience difficulty in finding replacement parts for maintaining installed PLCs. The facility is at risk of losing processes or equipment where OWRF does not have redundancy for a PLC.

4.1.3. General Assessment of NFPA 820 requirements

The NFPA 820 code provides requirements for protection against fire and explosion hazards specific to wastewater treatment facilities and collection systems. The majority of OWRF was constructed before

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NFPA 820 code was adopted by the City which makes most of the facilities non-compliant. This is critical for the headworks, grit, primary treatment and solids areas.

The code uses area classification to establish the level of combustible gas and fire monitoring and mitigation needed. The facilities can be classified as Class 1, Div 1; Class 1, Div 2; or Unclassified. The classification is dependent on whether the facility is open to atmosphere or enclosed. For the latter, the ventilation level will also dictate whether the facilities are Class 1, Div 1 or Class 1 Div 2.

The classification dictates the level of protection needed for electrical equipment and devices including motors, panel enclosures, device enclosures etc. The improvement costs associated with NFPA compliance are included in the electrical costs listed under each facility.

4.1.4. Headworks Building

4.1.4.1. Structure and Building

The headworks building was built in 1957 and has not undergone any upgrades or rehabilitation. The structure is beyond its expected life and is in very poor condition. As previously noted, the building is most likely not in compliance with current seismic codes and design criteria and may be vulnerable during an earthquake event. During an earthquake, OWRF may lose the ability to use the building and process equipment such as its screening unit. The building has received a safety rating of 4 indicating moderate potential for severe injury. Figure 4, Figure 5, and Figure 6 show the deterioration of the headworks building.

4.1.4.2. Mechanical Equipment and HVAC

One of the washer-compactors in the headworks building failed and has been removed from service. Step screens No. 1 and No .3 have exceeded their expected life and carry a medium criticality rating. The West air handler was installed in 2008 and is 2 years beyond its expected life but was assigned as a moderate risk.

4.1.4.3. Electrical

The electrical panel and transformer have exceeded their expected life with a high criticality. They are recommended for prioritized replacement. This facility is not compliant with NFPA 820 which represents a safety risk and hazard.

4.1.4.4. Instrumentation and Control

The PLC cabinet in the headworks building was installed in 2008, and it is 10 years beyond its expected life and at high risk of failure. OWRF staff report that the technology used in this PLC is outdated and replacement parts are difficult to find which puts the facility at risk of loss of functionality of process equipment. Similarly, control panels for other equipment such as step screens, screenings conveyor, and wet well pumps lack redundancy and require substantial maintenance.



Figure 4 – Spalling of concrete at the beam, cracks on walls, discoloration on walls due to seepage of water through cracks at Headworks Building



Figure 5 – Condition of Headworks Building wall near Aerated Grit Channel



Figure 6 – Cracks on Headworks Building near overhead door

4.1.5. Aerated Grit and Aerated Grit Blower Building

The majority (77%) of the assets associated with the aerated grit channel are recommended for immediate replacement. OWRF staff report the grit channels lack redundancy due to hydraulic limitations and they are unable to remove a channel from service for routine maintenance.

4.1.5.1. Structure and Building

The aerated grit channels No. 1 and 2 were built in 1983. Aerated grit channel No. 1 and No. 2 are near the end of its useful life. Both the channels are in poor condition and has exceeded its useful life by more than 21 years. The aerated grit blower building is also in poor condition. The structure was built in 1983 and is in need of immediate replacement.

4.1.5.2. Mechanical Equipment and HVAC

Most of the equipment was installed in 1983 and it is 20 to 35 years beyond its expected life with an average risk rating of four (4), indicating high criticality and in need of immediate replacement. OWRF staff cannot inspect and perform maintenance on the diffusers due to a lack of redundancy. The piping associated with pumps and air lift valves leaks. Figure 7 shows leaking pipes at the aerated grit channels.

4.1.5.3. Electrical

The gate actuators are in good condition with considerable remaining life. However, the electrical conduits at the grit basins are deteriorating with visible wires which results in an unsafe condition. This condition has received a safety rating of 4 or 5. This facility is not compliant with NFPA 820 which can present a safety hazard.

4.1.5.4. Instrumentation and Control

The valve and pump controls are at very high risk, are 23 years beyond their expected useful life, and require immediate replacement.



Figure 7 - Worn out and leaking air piping at Aerated Grit

4.1.6. Primary Clarifiers

4.1.6.1. Structure and Building

All primary clarifiers were built in 1957, but the structures appear to be in good condition.

4.1.6.2. Mechanical Equipment and HVAC

The primary clarifier mechanisms were upgraded in 2012 and are reported to be in good condition.

4.1.6.3. Electrical

The electrical disconnects on all clarifiers show a high degree of corrosion which suggest a high risk and criticality. It is recommended, these be prioritized for replacement. Figure 8 shows an electrical disconnect at the clarifier mechanism. The placement of the electrical devices should be checked for compliance with NFPA 820.

4.1.6.4. Instrumentation and Control

The instrumentation and control devices appear to be in good condition.



Figure 8 - Electrical disconnect at the Primary Clarifiers

4.1.7. Primary Sludge Pump Building

4.1.7.1. Structure and Building

The primary sludge pump building was built in 1983. It is 20 years beyond its expected useful life. It is recommended for prioritized replacement. The building has received safety rating of 4 indicating moderate potential for severe injury. Figure 9, Figure 10 show cracks at the primary sludge pump building.

4.1.7.2. Mechanical Equipment and HVAC

The primary sludge pumps are in poor condition and have exceeded their service life. OWRF staff indicated that the primary sludge pumps are unable to pump solids at the design concentration of 3%. This forces the facility to pump sludge at lower concentrations which causes hydraulic overloading of the biosolids system. It is recommended that OWRF plan to replace the pumps.

4.1.7.3. Electrical

The electrical disconnects are old and at high risk. Similarly, the VFD panel is relatively old and at high risk and should be considered for priority replacement.

4.1.7.4. Instrumentation and Control

The sludge pump and VFD control panel are in poor condition and at high risk of failure. These are recommended to be prioritized for replacement. The flow meters are in good condition. Figure 11 shows an electrical disconnect and VFD control panel at the primary sludge pump building.



Figure 9 – Cracks inside the Primary Sludge Pump Building



Figure 10 - Cracks inside the Primary Sludge Pump Building



Figure 11 - VFD panel, electrical disconnect at Primary Sludge Pump Building

4.1.8. Mixed Flow Pump Station and Screw Pump station

4.1.8.1. Structure and Building

The mixed flow pump station was built in 2010 and is in good condition. The screw pump station is in poor condition and only used during high flow conditions as required or when one of the mixed flow pumps is out of service. Thus, it is not primarily used for pumping wastewater from the clarifiers to bioreactors. The condition evaluation of the screw pump station structure suggests that it should be considered for replacement. However, adding redundancy to the mixed flow pump station, as discussed below, is considered more advantageous than upgrading the screw pump station. **Figure 13** shows the screw pump station.

4.1.8.2. Mechanical Equipment and HVAC

The screw pump system is very old and at high risk. Currently, there is one screw pump that has a broken bottom bearing housing and cannot be used until repaired. The mixed flow pumps were upgraded in 2020 and are considered in good condition. OWRf staff rely on the screw pump system for redundancy as the mixed flow pumps cannot meet current flow requirements with one mixed flow pump out of

service. OWRF should consider installing a redundant mixed flow pump or upgrading the screw pump station to provide system redundancy. Figure 12 shows three mixed flow pumps.

4.1.8.3. Electrical

The VFDs for the mixed flow pumps are reported to be in satisfactory condition.

4.1.8.4. Instrumentation and Control

The level instruments, high-level and low-level floats controlling the mixed flow pumps are at high risk of failure. It is recommended that they be prioritized for replacement. The electrical control panels for the screw pumps are also at high risk. OWRF should plan on replacing those control panels if they decide to continue using the screw pumps.



Figure 12 - Mixed Flow Pump Station



Figure 13 – Screw Pump Station

4.1.9. Bioreactors

4.1.9.1. Structure and Building

Bioreactors No. 1 and No. 2 were built in 1983. The structures are exhibiting signs of deterioration and questionable condition. It is recommended that OWRF plan scheduled rehabilitation of Bioreactors No. 1 and No. 2. Figure 14 and Figure 15 show cracks at bioreactors. Figure 16 shows sludge on the pavement near Bioreactor No. 1 indicating that the mixed liquor is seeping through the wall cracks. This could eventually affect the structural integrity of the walls by causing rebar corrosion and concrete degradation. The construction of Bioreactor No. 3 was completed in 2012. The bioreactor appears to be in good condition.

4.1.9.2. Mechanical Equipment and HVAC

The air distribution systems of all three bioreactors are reported to be in very poor condition and at high risk of failure. OWRF staff report that the air distribution system needs frequent and extensive maintenance. OWRF staff indicates that the 40-foot long lateral air distribution piping system is improperly supported and sways considerably. The air distribution system is recommended for immediate replacement.

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The surface aerators installed in 1984 in Bioreactors No. 1 and No. 2 have questionable efficiency and are at high risk of failure. The surface aerators are beyond their serviceable life and recommended for immediate replacement. OWRF staff mentioned that the drum mixer in Bioreactor No. 3 dislodged from its connection in 2021. Figure 17 shows the Bioreactor No. 2 surface aerator.

4.1.9.3. Electrical

The VFDs for internal mixed liquor Pump No. 1 and No. 2 and the mixer at Bioreactor No. 3 are at high risk of failure and nearing the end of their expected useful life. It is recommended that OWRF should monitor those VFDs and take necessary steps as needed.

4.1.9.4. Instrumentation and Control

The level sensors in all three bioreactors are in very poor condition and are at critical risk of failure. These instruments are recommended for replacement prioritization.



Figure 14 – Bioreactor No. 2 Cracks



Figure 15 – Spalling of concrete and cracks on Bioreactor No. 2 walls



Figure 16 – Sludge on pavement near Bioreactor No.1



Figure 17 – Surface aerator in Bioreactor No. 2

4.1.10. Bioreactor Blower Building

The bioreactor blower building contains six aeration blowers and one of the two standby power generators at OWRF.

4.1.10.1. Structure and Building

The blower building is in good condition with more than 24 years of expected useful life. The diesel day-tank installed in 1984 is 38 years old and at high risk of failure. The diesel tank is recommended for immediate replacement.

4.1.10.2. Mechanical Equipment and HVAC

The mechanical equipment and HVAC units are in good condition. The building is in need of air conditioning in the blower room to maintain constant temperature in the summer months.

4.1.10.3. Electrical



Figure 18 - Generator batteries at Bioreactor Blower Building

The generator battery charger and ATS are in poor condition and at high risk of failure. They are recommended for immediate replacement. The HVAC unit MCC is in poor condition and should be scheduled for replacement. Figure 18 shows generator battery charger at bioreactor blower building.

4.1.10.4. Instrumentation and Control

The instrumentation and control assets are in good condition.

4.1.11. Secondary Clarifiers

4.1.11.1. Structure and Building

Secondary clarifiers No. 5 and No. 6 were built in 1984 and appear to be in good condition in spite of exceeding their expected useful life. Secondary clarifiers No. 7 and No. 8 were built in 1999 and 2012, respectively and are in good condition and have remaining useful life. Secondary Clarifiers No. 7 and No. 8 splitter box is in poor condition and at high risk of failure. OWRF staff has indicated a lack of flow control at the splitter box. OWRF should plan to upgrade the splitter box.

4.1.11.2. Mechanical Equipment and HVAC

Secondary Clarifiers No. 5 and No. 6 mechanisms are 20 years beyond their expected useful life and are reported to be in poor condition. OWRF staff report that they are unable to find replacement components for the clarifier mechanisms, and it is difficult to maintain them. OWRF staff has indicated that they already requested City approval for upgrading the clarifier mechanism. Secondary Clarifier No. 5 and No. 6 do not have influent gates and OWRF staff uses fiberglass stop logs for isolation and flow splitting. It is recommended that gates be installed for effective flow control and safer operation. The influent slide gates and motorized actuators at Secondary Clarifier No. 7 and No. 8 are in poor condition with less than 1 year of remaining life. It is recommended that these gates be considered for planned replacement. The sump pumps on Secondary Clarifiers No. 5 and No. 6 are at high risk and are recommended for immediate replacement. Figure 19 shows Secondary Clarifier No. 5 center well components that are exhibiting signs of corrosion.

4.1.11.3. Electrical

The electrical disconnect on all clarifiers are at high risk and suggested for prioritized replacement. The electric actuators on Secondary Clarifier No. 7 and No. 8 are damaged and not functioning. The actuators are recommended for planned replacements.

4.1.11.4. Instrumentation and Control

The level sensors on Secondary Clarifier No. 7 and No. 8 have exceeded their expected useful life and are not functioning. These instruments are suggested for scheduled replacement.



Figure 19 – Clarifier No. 5 Center Well

4.1.12. RAS and WAS Pump Building, and Generator Building

The RAS and WAS pump building contains one of the two standby power generators at OWRF.

4.1.12.1. Structure and Building

The building was built in 1984 and appears to be in poor condition with a high risk of failure. The building has received a safety rating of 4 indicating a moderate potential for safety hazards.

4.1.12.2. Mechanical Equipment and HVAC

The WAS pumps are in good condition with medium criticality and have approximately 5 years of remaining useful life. The existing WAS piping is carbon steel and failing due to internal corrosion. The piping should be scheduled for immediate replacement.

The HVAC system components such as the louvers, ventilator, and A/C unit are at medium criticality and recommended for scheduled replacement.

4.1.12.3. Electrical

Bioreactors No. 1 and No. 2 aerator VFDs are very old and at high risk of failure. Similarly, the MCC panels and control center are recommended for immediate replacement. OWRF staff indicates that the electrical panels and accessories are outdated, undersized, and lack redundancy. Due to their age, replacement parts are not readily available. If OWRF loses an MCC or VFD, the facility will not be able to operate the equipment associated with the building.

The generator ATS, disconnect switch, battery charger and exhaust silencer are beyond their expected useful life, but are still operational with questionable condition. It is recommended that these assets be monitored for any required actions. If OWRF loses the generator, then the facility will not be operational during a power failure. They are, therefore, recommended for prioritized replacement. Figure 20 shows the generator in the building.

4.1.12.4. Instrumentation and Control

The RAS flow meters No. 1 and No. 2, WAS flow meter, sump level meter, and sump pump floats are all in very poor condition with a high risk of failure. They are recommended for prioritized replacement.



Figure 20 – Generator showing the exhaust system

4.1.13. UV Building

4.1.13.1. Structure and Building

The building is in very good condition and has more than 25 years of remaining life. However, OWRF staff are experiencing hydraulic limitations while treating peak hour flows through two UV trains. The existing UV channels do not provide required redundancy and the facility may be at risk of not meeting permit for disinfection requirements if one of the channels is out of service. OWRF should consider building a redundant channel or refurbishing the existing chlorine disinfection system to provide disinfection redundancy.

4.1.13.2. Mechanical Equipment and HVAC

The UV channels influent and effluent gates are in poor condition and at high risk of failure. They are recommended for immediate replacement. The HVAC equipment in the building is also in poor condition and is recommended for prioritized replacement.

4.1.13.3. Electrical

The UV modules are in good condition but are at critical risk of failure due to lack of redundancy, flexibility and insufficient capacity to handle observed peak hour flows. OWRF staff should proactively monitor the system and take necessary steps as required. The influent and effluent gate actuators are in poor condition and at high risk of failure. They are recommended for prioritized replacement. Figure 21 shows two actuators at the effluent gate at UV channels.

4.1.13.4. Instrumentation and Control

The UV system control panel serves both UV trains and lacks redundancy. If the control panel fails, OWRF will not meet its secondary effluent disinfection requirement. If OWRF chooses to build a redundant UV channel, the additional UV modules should be provided with their dedicated control system to provide required redundancy.



Figure 21 – UV Channel influent and effluent gates with actuators.

4.1.14. Chlorine Building

4.1.14.1. Structure and Building

OWRF is not currently using its chlorine building and has not indicated an alternate use of the building. However, OWRF staff indicate that the sump pump structure needs immediate replacement or improvements.

4.1.14.2. Mechanical Equipment and HVAC

The Parshall flume and sump pumps are in poor condition with a high risk of failure. OWRF staff indicates that immediate replacement is necessary.

4.1.14.3. Electrical

The 120V and 480V electrical panels were installed in 1985 and are at high risk of failure. They are recommended for immediate replacement.

4.1.14.4. Instrumentation and Control

The sump control panel has exceeded its expected useful life and is at high risk of failure. For the continued operation of the sump pump, the control panel is recommended for immediate replacement.

4.1.15. Dissolved Air Floatation (DAF)**4.1.15.1. Structure and Building**

The building and concrete structure was built in 2001 and have more than 15 years of remaining useful life. It should be noted that the facility has no redundancy for this process unit. If the unit fails, the facility cannot waste from the secondary process.

4.1.15.2. Mechanical Equipment and HVAC

The DAF mechanism and motor is 21 years old and in poor condition. The OWRF biosolids process was designed to thicken solids to 3% concentration. Currently, the DAF is not capable of producing this concentration of thickened solids. For improved biosolids processing, the DAF mechanism and motor are recommended for immediate replacement. Recirculation pumps pumps No. 1 and No. 2 are diaphragm pumps and are in poor condition and near the end of their service life. OWRF staff indicated issues with the pump seals that is impacting pump performance. Figure 22 shows the DAF mechanism.

4.1.15.3. Electrical

The DAF starter panel and drive motor are in very poor condition with a high risk of failure and are recommended for immediate replacement. Recycle Pump No. 1 and No. 2 VFDs and electrical disconnects are at critical risk of failure and have been in operation beyond their expected useful life. They are recommended for prioritized replacement. OWRF staff indicates that North and South 480V electric panels are in very poor condition and require immediate replacement. Figure 23 shows the electrical disconnect for recycle pumps.

4.1.15.4. Instrumentation and Control

The PLC controlling the DAF is not functioning. The control panel for the DAF, diaphragm pumps, and air entrainment tank are also at high risk of failure. The components of panels are difficult to find and replace and in case of failure the DAF process will be difficult to operate.



Figure 22 – DAF Basin



Figure 23 – Electrical disconnects and recycle pumps at the DAF

4.1.16. Thermophilic Digester

4.1.16.1. Structure and Building

The thermophilic digester building and concrete tanks were built in 2012 and have more than 20 years of remaining expected useful life.

4.1.16.2. Mechanical Equipment and HVAC

The methane and natural gas boilers in the thermophilic digester building are in very poor condition with high criticality even though they have been in operation for only 12 years (half of their expected useful life). OWRF staff has indicated that the pressure regulator valve and flame trap assembly on the thermophilic digester are not operating properly. The odor control unit in the building is not treating odor effectively and is recommended to be scheduled for replacement. The digester drain pump is in satisfactory condition and suggested for scheduled replacement. Figure 25 shows the odor control unit.

4.1.16.3. Electrical

OWRF staff indicates that the electrical panel LP-TD is at high risk of failure and recommended for continued monitoring. The remainder of the electrical system is in satisfactory condition.

4.1.16.4. Instrumentation and Control

OWRF staff report that all the atmospheric monitors in the thermophilic digester building are non-functioning creating a safety hazard. They are recommended for immediate replacement. The digester sludge level sensor is at high risk of failure and in very poor condition. The remainder of the instrumentation and control system is in good condition. Figure 24 shows the atmospheric monitor in the building.

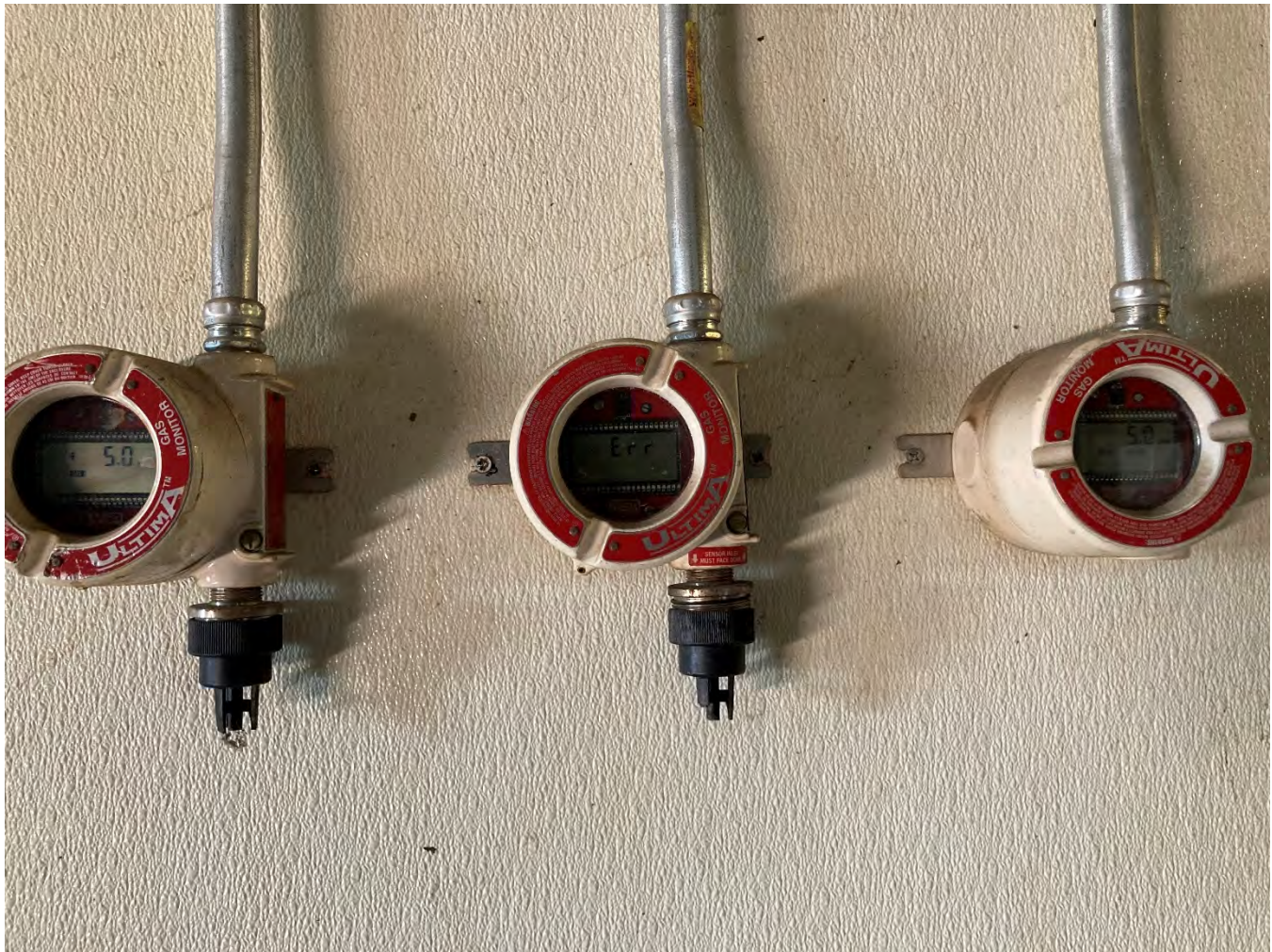


Figure 24 - Atmospheric monitors



Figure 25 – Odor Control unit at Thermophilic Digester

4.1.17. Mesophilic Digesters

4.1.17.1. Structure and Building

Both mesophilic digester tanks and the digester building were built in 1957 and are at critical risk of failure. Additionally, the secondary digester’s floating lid is in poor condition. These structures are

recommended for immediate replacement. Figure 26 and Figure 27 show the floating lid on the secondary mesophilic digester and cracks on the digester tank.

4.1.17.2. Mechanical Equipment and HVAC

The primary digester mixer has been in service beyond its expected useful life, and it is at critical risk of failure. OWRF staff has indicated that the pressure regulator valve and flame trap assembly on both digesters are not functioning properly resulting in safety and odor issues. They are recommended before immediate replacement.

4.1.17.3. Electrical

The MCC in the building was installed in 1984 and it is in very poor condition. The MCC is recommended for immediate replacement due to increased O&M and difficulty in finding replacement components. The 120V breaker panel and VFD are very old and OWRF staff report that they are difficult to maintain, and replacement parts are difficult to find. These electrical components are recommended for prioritized replacement.

This facility is not compliant with NFPA 820 which can present a safety hazard.

4.1.17.4. Instrumentation and Control

The digester gas manometer was installed in 1988. It is at high risk of failure and is recommended for immediate replacement. The digester sludge flow meter, gas flow meter, and digester control HMI panel are in poor condition and have been operating in excess of their expected useful life. They are recommended for prioritized replacement.



Figure 26 – Floating cover and mixer on mesophilic digester



Figure 27 - Cracks on mesophilic digester tank

4.1.18. Aerobic Digesters

The aerobic digester is currently used as a holding tank. Very few assets in the aerobic digester are in need of immediate replacement. However, approximately 79% of its listed assets are in the category of being recommended for prioritized replacement. The assets in the downstairs area of the building are prone to flood damage.

4.1.18.1. Structure and Building

The blower building and digester tanks are in satisfactory condition.

4.1.18.2. Mechanical Equipment and HVAC

OWRF staff report that mechanical equipment such as grinders and valves are functioning but corroded. The HVAC equipment, such as the ventilator and heater were installed in 1996 and have operated beyond their expected useful life. The HVAC equipment is in poor condition and at high risk of failure. Blowers No. 1 and No. 2 are in extremely poor condition and have been in operation for more than 30 years, well above their expected useful life. The odor control unit is not performing effectively and it is beyond its expected useful life. These assets are recommended for prioritized replacement. Figure 28 shows grinder pumps.

4.1.18.3. Electrical

All the MCC panels are at high risk of failure and in poor condition. It is difficult to find replacement parts for these panels. They are recommended for immediate replacement. Other electrical equipment such as the VFD, valve actuators, distribution panel, transformer, and electrical disconnect are all in poor condition but with medium criticality. These components are very old and it is difficult to find replacement components. They are recommended for prioritized replacement.

This facility is not compliant with NFPA 820 which can present a safety hazard. The MCCs are located near the exit door which could create a fire and safety hazard.

4.1.18.4. Instrumentation and Control

The blower control panel, sludge pump, and VFD control panel are at high risk of failure and are recommended for prioritized replacement. Figure 29 shows the blower control panel.



Figure 28 – Grinder pumps at Aerobic Digester Building



Figure 29 - Blower control panel at Aerobic Digester Building

4.1.19. Biosolids Building

4.1.19.1. Structure and Building

The biosolids building was built in 1994 and is adequate for the current loading conditions. The building is in acceptable condition with high criticality. It is recommended for monitoring and OWRf should consider necessary upgrades as required.

4.1.19.2. Mechanical Equipment and HVAC

Belt Press No. 1 and No. 2 installed in 1994 are in poor condition. The belt presses have been in operation beyond their expected service life. Also, OWRf staff indicated that the belt presses are not producing the expected solids content in the dewatered sludge and require a considerable amount of wash water which increases side stream return flows. OWRf staff has indicated that they are in process of upgrading the dewatering process. OWRf staff report that the air handlers in the biosolids building incur very high annual repair costs. The biosolids distribution auger is in poor condition and at high risk of failure. The odor control unit and accessories were installed in 1994 and are not functioning effectively. The

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conveyor belt is worn and is a single point of failure (no redundancy). These assets are recommended for immediate replacement. Figure 30 shows the belt press and cover.

4.1.19.3. Electrical

The MCC and VFD are operating beyond their expected useful life and are at high risk of failure. The MCC is located in lunchroom posing a severe safety hazard. The 480V/120V transformer is in satisfactory condition but at high criticality. This electrical equipment needs to be replaced for the continued operation of the biosolids building. This facility is not compliant with NFPA 820 which is an increased safety hazard. However, OWRF is in the process of completing an upgrade project.

4.1.19.4. Instrumentation and Control

Belt Press No. 1 and No. 2 control panels, feed pumps, pressate pump control panel, and distribution auger control panel have high criticality and are in poor condition. Belt Press No. 1 and No. 2 flow meters and pressate pump wet well level sensor are at high risk of failure and recommended for immediate replacement. The level meter at the biosolids hopper and atmospheric monitoring system are also in very poor condition. These are recommended for prioritized replacement. Figure 31 shows the belt press control panel.



Figure 30 – Belt Press and cover at Biosolids Building



Figure 31 - Belt Press control panel

4.1.20. Flare Stack

4.1.20.1. Structure and Building

The building is in satisfactory condition with more than 10 years of expected remaining useful life.

4.1.20.2. Mechanical Equipment and HVAC

The flare stack is in satisfactory condition with high criticality. It is recommended for prioritized replacement as well as installing a redundant flare stack. The rest of the assets are in good condition. Figure 32 shows the flare stack near the thermophilic digester. It is recommended that OWRF install flow measurement for the digester gas stream.

4.1.20.3. Electrical

While the electrical assets are in good condition, there are items in the building that do not meet the NFPA 820 code for the waste gas burner. This building should be considered for upgrade.

4.1.20.4. Instrumentation and Control

The flow switch in the flare building is in satisfactory condition with high criticality. It is recommended for prioritized replacement.



Figure 32 – Flare stack near Thermophilic Digester

4.1.21. Drying Beds

4.1.21.1. Structure and Building

The concrete structure of two lagoons near the drying beds is 65 years old and in very poor condition. The lagoon and liner are recommended for an immediate replacement to prolong their beneficial use.

4.1.21.2. Mechanical Equipment and HVAC

There are no mechanical and HVAC assets.

4.1.21.3. Electrical

There are no electrical assets.

4.1.21.4. Instrumentation and Control

There are no instrumentation and control assets.

4.1.22. Miscellaneous Buildings

Various non-process buildings such as the administration building, maintenance shop, compressor building, impure pump building, and pump storage/trickling filter building are considered in this section.

4.1.22.1. Structure and Building

The administration building, compressor building, and impure pump building are in satisfactory condition. The maintenance shop building is near the end of its useful life and is in poor condition. The building was rated a 4 for safety indicating moderate potential for severe injury. It is recommended for prioritized replacement or upgrades. Figure 33 shows the maintenance shop building deterioration.

4.1.22.2. Mechanical Equipment and HVAC

The three pumps in the impure pump building are near the end of their useful life with medium criticality. They should be planned for scheduled replacement. Figure 34 shows the pumps at the impure pump building.

The heater in the maintenance shop building has operated beyond its expected useful life and is in poor condition. It is recommended for prioritized replacement

4.1.22.3. Electrical

The MCC in the impure pump building is very old. It is at high risk of failure and in poor condition. It is recommended for immediate replacement. The mesophilic digester MCC panel in the pump storage/trickling filter building is in poor condition with high criticality. It is recommended for prioritized replacement.

4.1.22.4. Instrumentation and Control

There are no instrumentation and control assets requiring attention or replacement.



Figure 33 – Deterioration at Maintenance Shop Building



Figure 34 - Pumps at Impure pump Building

4.2. Replacement Priority By Criticality and Risk

4.2.1. Interpretation of Results

It is important to note that the purpose of the analysis presented in paragraphs 4.2.2, 4.2.3 and 4.2.4 is not to predict when a structure or equipment will fail, but rather to provide a representation of the relative risk of failure for a structure or equipment. The anticipated relative risk of failure may be a positive or negative number. If the risk of failure of an asset is zero or below, it has already reached its expected useful life by industry standards and is considered to have a relatively high risk of failure. As the risk of failure value becomes more negative for an asset, that asset is considered more likely to fail. The intent of the tables above is not to report that all the listed structures and equipment units are going to fail within the next few years, but to relate that many of the structures and equipment units are at a high risk of failure based on an analysis of their age, use, condition, and performance. If the equipment or structure is critical to the operation of the facility, then its high risk of failure can be associated with a

high risk that the facility will incur impaired operation, create a risk to the health and/or safety of operations staff, or otherwise fail to meet its intended use.

4.2.2. High Criticality and High Risk of Failure Assets

Assets with high criticality and high risk of failure are recommended to be upgraded or replaced immediately. These items are shown in Table 4-1.

Table 4-1 High Criticality and High-Risk Assets

Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
Headworks Building				
PLC/HMI Cabinet	2008	4	4	-10.0
Structure	1957	4	5	-41.0
Aerated Grit and Aerated Grit Blower Building				
Aerated Grit Pump/Valves Control Panel	1985	4	4	-23.9
Air Lift Pump 1 - Channel 1	1983	5	4	-36.6
Air Lift Pump 1 - Channel 2	1983	5	4	-36.6
Air Lift Pump 2 - Channel 1	1983	5	4	-36.6
Air Lift Pump 2 - Channel 2	1983	5	4	-36.6
Air Lift Pump 3 - Channel 1	1983	5	4	-36.6
Air Lift Pump 3 - Channel 2	1983	5	4	-36.6
Air Lift Valve 1 - Channel 1	1983	5	4	-36.4
Air Lift Valve 1 - Channel 2	1983	5	4	-36.4
Air Lift Valve 2 - Channel 1	1983	5	4	-36.4
Air Lift Valve 2 - Channel 2	1983	5	4	-36.4
Air Lift Valve 3 - Channel 1	1983	5	4	-36.4
Air Lift Valve 3 - Channel 2	1983	5	4	-36.4
Channel 1 - Structure	1983	4	4	-21.7
Channel 1 Air Diffusers	1983	5	4	-37.6
Channel 1 Air Diffusers Supply Valve	1983	4	4	-23.6
Channel 1 Piping	1983	5	4	-35.9
Channel 2 - Structure	1983	4	4	-21.7
Channel 2 Air Diffusers	1983	5	4	-37.6
Channel 2 Air Diffusers Supply Valve	1983	4	4	-23.6
Channel 2 Piping	1983	5	4	-35.9
Grit Chamber Blower Building	1983	4	5	-21.7
PS Pump Building				
Penn Valley Primary Sludge Pump 1	2013	4	3	-1.0
Penn Valley Primary Sludge Pump 2	2013	4	3	-1.0

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Bioreactors				
BNR 1- Air Distribution System	2012	5	4	-11.0
BNR 1- BNR aerators/mixer 1	1984	3	4	-15.8
BNR 1- BNR aerators/mixer 2	1984	3	4	-15.8
BNR 2- Air Distribution System	2012	5	4	-11.0
BNR 2- BNR aerators/mixer 3	1984	3	4	-15.8
BNR 2- BNR aerators/mixer 4	1984	4	4	-24.7
BNR 3- Air Distribution System	2012	5	4	-11.0
Bioreactor Blower Building				
Diesel Day Tank	1984	3	5	-15.8
Generator ATS	2012	5	5	-11.0
Generator Battery Charger	1984	3	4	-18.6
Secondary Clarifiers				
5 & 6 Clarifier Sump Pump 1	1984	4	4	-23.0
Clarifier 5 Mechanism	2000	5	2	-20.5
Clarifier 6 Mechanism	2000	5	2	-20.5
RAS/WAS - Generator Building				
Electrical Switchgear	2001	4	5	-13.9
Generator Control Center	1984	3	5	-15.8
MCC - Generator Room	2001	5	5	-19.6
MCC3 panel	1984	4	5	-29.8
MCC5 panel	1984	4	5	-29.8
RAS/WAS Building	1984	4	4	-20.9
RAS/WAS Control center	1984	3	5	-24.4
Screw Pump 1	1984	4	4	-21.5
Screw Pump 1 Inlet Gate	1984	5	5	-35.8
Screw Pump 2	1984	4	4	-21.5
Screw Pump 2 Inlet Gate	1984	5	5	-35.8
Screw Pump 3	1984	4	4	-21.5
Screw Pump 3 Inlet Gate	1984	5	5	-35.8
Transformer 480 - 240/120 volt	2001	4	5	-12.5
VFD - BNR 1 Mixer 1	1984	3	4	-24.4
VFD - BNR 1 Mixer 2	1984	3	4	-24.4
VFD - BNR 2 Mixer 3	1984	3	4	-24.4
VFD - BNR 2 Mixer 4	1984	3	4	-24.4
UV Disinfection Building				
Effluent Gate Train 1	2014	4	4	-10.5
Effluent Gate Train 2	2014	4	4	-10.5
Influent Gate Train 1	2014	4	4	-10.5
Influent Gate Train 2	2014	4	4	-10.5

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UV Disinfection System Train 1 - Control Panel	2014	2	5	-10.5
UV Disinfection System Train 1 - Module 1	2014	2	5	-10.5
UV Disinfection System Train 1 - Module 2	2014	2	5	-10.5
UV Disinfection System Train 1 - Module 3	2014	2	5	-10.5
UV Disinfection System Train 2 - Control Panel	2014	2	5	-10.5
UV Disinfection System Train 2 - Module 1	2014	2	5	-10.5
UV Disinfection System Train 2 - Module 2	2014	2	5	-10.5
UV Disinfection System Train 2 - Module 3	2014	2	5	-10.5
Chlorine Building				
Electrical Panel 120V	1985	4	4	-23.9
Electrical Panel 480V	1985	4	4	-23.9
Sump Pump #1	1985	4	4	-23.4
Sump Pump #2	1985	4	4	-23.4
Sump Pump Control Panel	1985	4	4	-23.9
Sump Pump Structure	1985	4	4	-18.9
DAF				
DAF Starter Panel	2001	4	4	-12.5
Diaphragm Pump 1 Control Panel	2001	5	3	-19.5
Diaphragm Pump 2 Control Panel	2001	5	3	-19.5
North Electrical Panel - 480 volt	2001	4	4	-12.5
PLC Control Panel	2001	5	4	-20.3
South Electrical Panel - 480 volt	2001	4	4	-12.5
DAF Drive Motor	2001	4	4	-13.2
DAF Mechanism	2001	4	4	-12.5
Thermophilic Digester Building				
Atmospheric Monitor - Stairwell	2012	3	3	-3.1
Atmospheric Monitor 1	2012	5	3	-11.0
Atmospheric Monitor 2	2012	5	3	-11.0
Atmospheric Monitor 3	2012	5	3	-111.0
Burnham boiler 1 (Methane)	2012	5	5	-10.5
Burnham boiler 2 (Natural Gas)	2012	5	5	-10.5
Mesophilic Digester Building				
Digester Gas Manometer	1988	3	4	-20.4
MCC Meso Digester Building	1984	4	5	-29.8
Meso Building	1957	3	4	-24.2
Primary Digester Flame Trap	1996	5	4	-23.9
Primary Digester Mixer	2004	5	4	-16.7
Primary Digester PRV/VRV	1996	5	4	-23.9
Primary Digester Tank	1957	3	4	-24.2
Secondary Digester Flame Trap	1996	5	4	-23.9

L:\Engineering\Projects\21-027 Orem WRF Improvements Plan_{S}\09 Reports\Task 1 Tech Memo\Info Request Tech Memo DRAFT FINAL 200603.docx

Secondary Digester PRV/VRV	1996	5	4	-23.9
Secondary Digester Tank	1957	3	4	-24.2
Secondary Floating Lid	2004	4	5	-10.2
Aerobic Digesters				
Electrical Distribution Panel (downstairs) - 480 Volt	1996	5	5	-24.3
Electrical Distribution Panel A - 480 Volt	1996	5	5	-24.4
Electrical Transformer - 480 V to 208/120 V	1996	5	3	-24.4
Lampson Blower 1	1984	5	3	-35.6
Lampson Blower 2	1984	5	3	-35.6
MCC-4 Panel	1984	5	5	-36.6
MCC-AD Panel	1984	5	5	-36.6
Sludge Pump 1 Control Panel	1996	5	5	-24.4
Sludge Pump 1 Electrical Disconnect	1996	5	5	-24.4
Sludge Pump 1 VFD Panel	1996	5	5	-24.6
Sludge Pump 2 Control Panel	1996	5	5	-24.4
Sludge Pump 2 Electrical Disconnect	1996	5	5	-24.4
Sludge Pump 2 VFD Panel	1996	5	5	-24.6
Biosolids Building				
Biosolids Distributor Auger	1994	3	4	-10.7
Compressor Tank	1994	3	4	-10.7
Control Panel - Press 1	1994	3	4	-10.7
Control Panel - Press 2	1994	3	4	-10.7
Control Panel - Press Feed Pumps	1994	3	4	-10.7
Deionized Water System	1994	3	4	-10.7
Distributor Auger Control Panel	1994	3	4	-10.7
Flow Meter - Press 1	1994	4	4	-20.1
Flow Meter - Press 2	1994	4	4	-20.1
Level Meter - Pressate Pump Wetwell	1994	3	4	-14.8
Odor Control System	1994	4	4	-17.6
Odor Control System - Supply Fan	1994	4	4	-18.1
Odor System Control Panel	1994	4	4	-17.6
Odor System Local Control Panel	1994	4	4	-17.6
Potable Water Backflow Assembly - Press Room East	1994	4	4	-15.0
Potable Water Backflow Assembly - Shop Lower	1994	4	4	-15.0
Potable Water Backflow Assembly - Shop Upper	1994	4	4	-15.0
Press 1 Polymer Mixing Valve	1994	4	4	-15.0
Press 2 Polymer Mixing Valve	1994	4	4	-15.0
Press Room Air Handler 1	1994	4	4	-17.6
Press Room Air Handler 2	1994	4	4	-17.6

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Pressate Pump Control Panel	1994	3	4	-10.7
Sludge Conveyor System	1994	3	4	-10.7
Water Softener System	1994	3	4	-10.7
Drying Beds				
Lagoon - East	1957	5	4	-59.7
Lagoon - West	1957	5	4	-59.7
Impure Pump Building				
MCC - Impure Pump Building	1984	3	4	-24.4

4.2.3. High Priority Replacements or Upgrades

Assets with medium criticality and high risk of failure or high criticality and medium risk of failure should be scheduled for replacement or upgrade and flagged as high priority. These items are shown in Table 4-2.

Table 4-2 High Priority Replacement and Upgrades

Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
Headworks Building				
Conveyor System Final (rubber)	2008	3	4	-1.9
Conveyor System Final (rubber) Control Panel	2008	3	4	-2.2
Differential Level Meter	2009	3	4	-4.8
Headworks 240/120 V Electrical Panel	2008	3	4	-2.2
Headworks 480/120 V Transformer	2008	3	4	-4.1
Headworks 480/277 V Electrical Panel	2008	3	4	-2.2
Overhead door #1 electric opener	2001	4	3	-11.7
Overhead door #2 electric opener	2001	4	3	-11.7
Rag Washer Control Panel	2008	3	4	-2.2
Screenings Conveyor Control Panel	2008	4	4	-6.9
Step Screen Control Panel	2008	4	4	-6.9
Wet Well Pump Control Panel	2001	4	3	-12.5
Primary Clarifiers				
Clarifier 1 Electrical Disconnect	2012	3	4	-1.2
Clarifier 2 Electrical Disconnect	2012	3	4	-1.2
Clarifier 3 Electrical Disconnect	2012	3	4	-1.2
Clarifier 4 Electrical Disconnect	2012	3	4	-1.2
PS Pump Building				
Building	1983	4	3	-21.7
Electrical Disconnect - East	2006	3	4	-3.6
Electrical Disconnect - Main Power Breaker	2006	3	4	-3.6

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Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
Electrical Disconnect - West	2006	3	4	-3.6
Electrical Panel - Main Panel Board	2006	3	4	-3.6
Overhead Door	1983	4	3	-21.7
Sludge Pump Control/VFD Panel	2013	3	4	-2.5
Mixed Flow Pump Station				
Mixed Flow Pump Level Meter	2012	4	4	-5.9
Mixed Flow Wet Well High Level	2012	3	4	-3.1
Mixed Flow Wet Well Low Level	2012	3	4	-3.1
Bioreactors				
BNR 1 - Level Meter	2012	4	4	-5.9
BNR 2 - Level Meter	2012	4	4	-5.9
BNR 3 - Anaerobic Basin 1 Splitter Box Level Meter	2012	4	4	-5.9
BNR 3 - Anaerobic Basin 2 Splitter Box Level Meter	2012	4	4	-5.9
BNR 3 - Anaerobic Basin No. 3 Inlet Box Level Meter	2012	4	4	-5.9
BNR 3 - Level Meter	2012	4	4	-5.9
Bioreactor Blower Building				
PLC Panel	2012	2	4	-1.4
Secondary Clarifiers				
5 & 6 Clarifier Sump Pump 2	1984	3	3	-13.0
Clarifier 5 Electrical Disconnect	2012	3	4	-1.2
Clarifier 6 Electrical Disconnect	2012	3	4	-1.2
Clarifier 7 Electrical Disconnect	1999	3	4	-9.0
Clarifier 7 RAS Weir Gate	1999	3	4	-2.6
Clarifier 7 Scum Pump	1999	3	4	-6.6
Clarifier 8 Electrical Disconnect	2012	3	4	-1.2
Clarifier 8 Scum Pump Electrical Disconnect	2012	3	4	-1.2
RAS/WAS - Generator Building				
208/120 volt breaker panel	2001	3	4	-6.9
Diesel Day Tank	2001	3	5	-6.9
Diesel Storage Tank	2001	3	5	-6.9
East Hoist	1984	3	3	-15.4
Generator ATS	2001	3	5	-6.9
Generator Disconnect Switch	2001	3	5	-6.9
Generator Exhaust Silencer - East	2001	3	5	-6.9
Generator Exhaust Silencer - South	2001	3	5	-6.9

Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
Generator Side Heater	1984	3	3	-15.8
Overhead Door - East	1984	3	3	-15.8
Overhead Door - West	1984	3	3	-18.6
Overhead Door Opener - West	1984	3	3	-18.6
RAS Flow Meter No.1 (CLR 5)	2012	3	4	-3.1
RAS Flow Meter No.2 (CLR 6)	2012	3	4	-3.1
RAS/WAS Pump Station Sump High High Level	2002	4	3	-13.1
RAS/WAS Pump Station Sump High Level A	2002	4	3	-13.1
RAS/WAS Pump Station Sump High Level B	2002	4	3	-13.1
RAS/WAS Pump Station Sump Low Level	2002	4	3	-13.1
Screw Pump Hoist	1984	4	3	-24.7
Screw Pump Level Meter	2012	3	4	-3.1
Standby Generator - 1.5 mW	2001	3	5	-4.5
Underground diesel tank	1996	3	5	-9.7
Veeder-Root TLS-300 System	2001	3	5	-8.0
Wall Ventilator - North	1984	3	3	-15.8
Wall Ventilator - South	1984	3	3	-15.8
WAS Flow Meter	2012	3	4	-3.1
West Hoist	1984	3	3	-12.0
UV Disinfection Building				
Effluent Gate Electric Actuator Train 1	2014	4	4	-3.0
Effluent Gate Electric Actuator Train 2	2014	4	4	-3.0
Influent Gate Electric Actuator Train 1	2014	4	4	-3.0
Influent Gate Electric Actuator Train 2	2014	4	4	-3.0
UV Building PLC/HMI Panel	2014	2	5	-0.7
UV Disinfection System AC	2014	4	5	-1.6
UV Disinfection System PLC Panel	2014	2	5	-0.7
Chlorine Building				
Parshall Flume - Effluent	1985	3	3	-15.2
Slide Gate 7 & 8 SC	1985	5	3	-33.9
Slide Gate West	1985	5	3	-33.9
DAF				
Air Entrainment Tank Control Panel	2001	3	5	-6.9
MCC panel	2001	3	5	-9.1
Recycle Pump #1 VFD	2001	4	3	-13.3
Recycle Pump #2 VFD	2001	4	3	-13.3

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Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
DAF Mechanism Control Panel	2001	3	4	-6.9
Drain Valve Electric Actuator	2001	3	4	-5.8
Thermophilic Digester Building				
Air Diaphragm Pump Control Panel 1	2012	4	4	-2.0
Air Diaphragm Pump Control Panel 2	2012	4	4	-2.0
Digester Tank Flame Trap	2012	2	4	-10.0
Digester Tank Flame Trap Assembly	2012	2	4	-10.0
Digester Tank PRV/VRV	2012	2	4	-10.0
Digester Tank Sludge Level Sensor	2012	2	4	-10.0
Electrical Panel LP-TD (208Y/120V)	2012	2	5	-10.0
Mesophilic Digester Building				
120 Volt Breaker Panel	1996	3	5	-9.7
Anaerobic Digester PLC/HMI Panel	2012	4	4	-6.5
Digested Sludge Flow Meter - EH	2012	3	4	-3.1
Digester Gas Flow Meter	2012	3	4	-3.1
Room Exhaust Ventilator	2012	3	4	-1.2
Sludge Flow Meter - EH	2012	3	4	-3.1
Spiral heat exchanger	1988	3	3	-13.6
VFD Allen Bradley	1996	3	3	-13.0
Aerobic Digesters				
Blower 1 Inlet Valve w/ Electric Actuator	1996	5	3	-24.4
Blower 1 Inlet Valve w/ Electric Actuator	1996	5	3	-24.4
Blower Control Panel	1996	5	3	-24.4
Blower Inlet Valve Control Panel	1996	5	3	-24.4
Clarifier 7 VFD Panel	1996	5	3	-24.7
East Air Header Valve with Electric Actuator	1996	4	3	-16.5
HMI Cabinet	1996	5	3	-25.3
Natural Gas Unit Heater	1996	5	3	-24.2
Odor Control Unit - Sludge Holding Tank	1996	4	3	-16.2
Sludge Grinder - East	1996	4	3	-15.5
Sludge Grinder - West	1996	4	3	-15.5
Unit Heater - Electric (downstairs)	1996	5	3	-24.2
Wall Ventilator - North Wall	1996	5	3	-24.2
Wall Ventilator - South Wall	1996	5	3	-24.3
West Air Header Valve with Electric Actuator	1996	4	3	-16.5
Biosolids Building				

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Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
2W Expansion Tank	1994	3	3	-10.7
Air Handler - Main Floor	1994	3	3	-10.7
Air Handler - Upper Floor	1994	3	3	-10.7
Ashbrook Belt Press 1	1994	4	3	-17.6
Ashbrook Belt Press 2	1994	4	3	-17.6
Atmosphere Monitoring System - Press Room	1994	4	3	-20.1
Atmosphere Monitoring System - Truck Bay	1994	4	3	-20.1
Biosolids Collection Hopper	1994	2	4	-2.0
Building	1994	3	4	-2.1
Chemical Feed Pump - Sodium Hydroxide	1994	5	3	-25.6
Chemical Feed Pump - T-Chlor	1994	5	3	-25.6
Compressor 2	1994	4	3	-16.8
Distributor Auger Slide Gate Left	1994	3	4	-6.3
Distributor Auger Slide Gate Right	1994	3	4	-6.3
Dry Keeper - Sanplatec Corp	2010	2	4	-2.5
Electrical Disconnect - 2W Booster Pump 1	1994	3	3	-10.7
Electrical Disconnect - 2W Booster Pump 2	1994	3	3	-10.7
Electrical Disconnect - 2W Booster Pump 3	1994	3	3	-10.7
Electrical Disconnect - Pressate Pump 1	1994	3	3	-10.7
Electrical Disconnect - Pressate Pump 2	1994	3	3	-10.7
Electrical Disconnect - Pressate Pump 3	1994	3	3	-10.7
Electrical Panel - A	1994	2	4	-2.0
Electrical Panel - B1	1994	2	4	-2.0
Hydraulic Fluid Tank 1	1994	3	3	-10.7
Hydraulic Fluid Tank 2	1994	3	3	-10.7
Idexx Quanti-Tray Sealer	2010	3	4	-5.7
Level Meter - Biosolids Collection Hopper	1994	3	3	-14.8
MCCA	1994	2	4	-8.1
Muffle Furness	2010	3	4	-5.7
Overhead Door Electric Opener - North Truck Bay	1994	3	3	-11.5
Overhead Door Electric Opener - South Truck Bay	1994	3	3	-11.5
Potable Water Backflow Assembly - Press Room West	1994	4	3	-15.0
Potable Water Pressure Regulator / Flow Control Panel	1994	4	3	-15.0
Press 1 Flow Control Valve	1994	3	4	-6.3
Scale - Scientech	2010	2	4	-2.5

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Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
Sludge Density Meter - Ohalis	2010	3	4	-5.7
Strainer - 2W Booster Pump 1	1994	3	3	-10.3
Strainer - 2W Booster Pump 2	1994	3	3	-10.3
Strainer - 2W Booster Pump 3	1994	3	3	-10.3
Transformer 480V/120V	1994	2	4	-3.3
Flare Building				
Flare Stack	2012	4	5	-3.4
Flow Switch	2012	3	5	-3.1
Drying Beds				
Bed 2 - Collections	1985	5	3	-34.0
Bed 3 - Collections	1985	5	3	-34.0
Maintenance Shop				
Building	1983	4	3	-21.7
Hoist	1983	3	3	-13.0
Shop Heater	1983	4	3	-25.4
Pump Storage Building/TF				
Meso Digester MCC panel	2012	4	5	-5.9

4.2.4. Schedule Asset Replacements or Upgrades

Assets with medium criticality and medium risk of failure or low criticality and high risk of failure should be scheduled for replacement or upgrade. These assets are listed in the following list by major treatment process area and general category:

Table 4-3 Assets to be Scheduled for Replacement or Upgrade

Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
Headworks Building				
Air Handler - West	2008	3	3	-2.2
BNR Bypass Flow Meter	2012	3	3	-3.1
Hoist	2001	3	3	-4.5
Influent Flow Meter	2012	5	3	-9.3
Step Screen 1	2009	3	3	-1.2
Step Screen 3	2009	3	3	-1.2
Aerated Grit Channels				

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Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
48" Palmer Bowles Flume	1985	2	3	-4.3
Primary Clarifiers				
Clarifier 1 Structure	1957	3	2	-24.2
Clarifier 2 Structure	1957	3	2	-24.2
Clarifier 3 Structure	1957	3	2	-24.2
Clarifier 4 Structure	1957	3	2	-24.2
PS Pump Building				
Gorman Rupp Diaphragm Pump	2006	3	3	-1.5
Bioreactors				
BNR 1 - Concrete Structure	1983	4	2	-20.6
BNR 2 - Concrete Structure	1983	4	2	-20.6
BNR Blower Building				
MCC HVAC Unit	2012	5	3	-8.9
Secondary Clarifiers				
Clarifier 7 Davit Crane	1999	3	3	-4.4
Clarifier 7 Flow Meter	1999	5	2	-21.8
Clarifier 7 RAS Box Level Meter	2002	3	3	-8.5
Clarifier 7 RAS Weir Gate Electric Actuator	1999	3	3	-9.0
Clarifier 7 Scum Pump Control Panel	1999	3	3	-8.1
Clarifier 7 Scum Slide Gate	1999	3	3	-2.6
Clarifier 7 Sludge Blanket Level Meter	1999	5	2	-21.4
Clarifier 7 Weir Washer	1999	4	2	-14.0
Clarifier 8 RAS Weir Gate Electric Actuator	2012	3	3	-1.2
Clarifier 8 RAS Box Level Meter	2012	3	3	-3.1
Clarifier 8 RAS Box Level Meter	2012	3	3	-3.1
Clarifier 8 Scum Box Level Meter	2012	3	3	-3.1
Distribution Box Level Meter (Flow CLR 7)	2012	3	3	-3.1
Distribution Box Level Meter (Flow CLR 8)	2012	3	3	-3.1
RAS/WAS - Generator Building				
AC Unit - roof mount	1998	3	3	-8.6
Diesel Filling Station	2001	3	3	-6.9
East Wall Louver	2001	3	3	-6.9
North Wall Louver	2001	3	3	-6.9
RAS/WAS valve actuator 1	2019	5	3	-1.2
RAS/WAS valve actuator 2	2019	5	3	-1.2
Screw pump wet well sump pump 1	1984	3	2	-10.9

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Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
Screw pump wet well sump pump 2	1984	3	2	-10.9
South Wall Louver 1	2001	3	3	-6.9
South Wall Louver 2	2001	3	3	-6.9
South Wall Louver 3	2001	3	3	-6.9
Unit Heater - Pump Room	1984	4	2	-24.7
VFD - Waste Pump 1	2002	3	3	-7.6
VFD - Waste Pump 2	2002	3	3	-7.6
Chlorine Building				
PLC/HMI Cabinet	2012	4	3	-6.5
DAF Building				
Digester Gas Booster Blower	2001	4	2	-10.9
Electrical Disconnect - Exterior	2001	3	3	-8.0
Flow Meter	2001	3	3	-9.1
Heater	2001	3	3	-6.9
Thermophilic Digester Building				
Air Filter (Basement)	2012	3	3	-3.1
EQ odor control unit	2012	4	3	-3.4
Gorman Rupp digester drain pump	2012	5	3	-8.3
Mesophilic Digester Building				
Atmospheric Monitor - Bottom	2012	5	3	-9.1
Atmospheric Monitor - Top	2012	5	3	-9.1
Belt Press Pump #1 VFD	2012	3	3	-2.6
Belt Press Pump #2 VFD	2012	3	3	-2.6
Hydraulic Lift Platform	1988	4	2	-18.4
Hydraulic Lift Platform Operator	1988	4	2	-18.4
Overhead Door	1988	3	2	-10.2
Biosolids Building				
Chemical Storage Tank - Sodium Hydroxide	1994	3	3	-5.4
Chemical Storage Tank - T-Chlor	1994	3	3	-5.4
Compressor 1	1994	2	3	0.0
Compressor Dryer - BelAir	1994	3	3	-9.4
Compressor Dryer - Kaser	1994	3	3	-9.4
Hydraulic Pump 1	1994	3	3	-9.7
Hydraulic Pump 2	1994	3	3	-9.7
Incubator - Fisher Scientific 307	2010	3	3	-4.6
Lab Instrument - HQ440D	2010	2	3	-2.5

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Description	Year Installed or Year of Major upgrade / Maintenance	Condition	Average Risk Assessment	Remaining Life (yrs)
Louver - Truck Bay East	1994	3	3	-9.4
Mixing Plate - Thermolyne	2010	2	3	-2.5
Overhead Door - North Truck Bay	1994	3	3	-2.1
Overhead Door - South Truck Bay	1994	3	3	-2.1
Safety Shower	1994	2	3	-2.0
Unit Heater - Truck Bay	1994	3	3	-9.4
Ventilator - Shop	1994	3	3	-9.4
Ventilator - Truck Bay	1994	3	3	-9.4
Water Heater - Gas	1994	2	3	-2.0
Impure Pump Building				
2W Pump 1	2000	3	3	-5.4
2W Pump 2	2000	3	3	-5.4
2W Pump 3	2000	3	3	-5.4
Maintenance Shop				
Compressor	1997	3	3	-6.5
Diesel Fueling Station	1983	3	2	-13.0
Gas Portable Compressor	1997	3	3	-6.5
Overhead Door East, North	1983	4	2	-21.7
Overhead Door East, South	1983	4	2	-21.7
Overhead Door Electric Opener East, North	1983	4	2	-27.3
Overhead Door Electric Opener East, South	1983	4	2	-27.3
Overhead Door Electric Opener West, Center	1983	4	2	-27.3
Overhead Door Electric Opener West, North	1983	4	2	-27.3
Overhead Door Electric Opener West, South	1983	4	2	-27.3
Overhead Door West, Center	1983	4	2	-21.7
Overhead Door West, North	1983	4	2	-21.7
Overhead Door West, South	1983	4	2	-21.7

APPENDIX F. **Odor Control Memorandum**



OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
ODOR CONTROL MEMORANDUM - DRAFT

OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
ODOR CONTROL MEMORANDUM

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Table of Contents

Executive Summary	4
1. Introduction	5
2. Background	5
3. Facility Location	5
4. Historical Odor complaints	7
5. Wind Rose for Orem	7
6. Existing Facilities Odor Evaluation	9
6.1 Headworks	9
6.2 Primary Treatment Process	11
6.3 Secondary Treatment Process	12
6.4 Solids Handling Facility	13
7. Odor Treatment Technologies	18
7.1 Chemical Feed	18
7.2 Foul Air Treatment	20
8. NFPA Considerations	26
9. Odor Improvements Recommendations	29
9.1 Headworks	29
9.2 Primary Treatment Process	30
9.3 Secondary Treatment Process	30
9.4 Solids Handling Facilities	30
10. Summary of Improvements	32



10.1 Headworks Wet Chemical Scrubber	32
10.2 Primary Treatment Area	33
10.3 Digesters and DAF Area Wet Chemical Scrubber	33
10.4 Sludge Holding Tanks	33
10.5 Biosolids Building	34
10.6 Sampling.....	34
10.7 Weather Station.....	35
10.8 HVAC evaluation	35
10.9 Proposed Location of Scrubbers	35

Table of Figures

Figure 1: Map showing the location of Orem Water Reclamation Facility (OWRF)	6
Figure 2 Location of Historical Odor Complaints	7
Figure 3: Wind Rose at Provo Municipal Airport from January 2017 to December 2020.....	8
Figure 4: Headworks building with gratings on channels and covered equipment	10
Figure 5: Aerated grit unit open to the atmosphere	11
Figure 6: Primary clarifier open to the atmosphere	12
Figure 7: Anaerobic basins with cannon air mixer.....	13
Figure 8: Dissolved Air Floatation (DAF) thickener open to the atmosphere	14
Figure 9: Chemical Scrubber unit for sludge holding tanks (right) and dewatering building (left).....	16
Figure 10: Odor collection hoods over dewatering equipment in Biosolids Building	18
Figure 11: Typical Low-Profile Wet Chemical Scrubber for Odorous Air Treatment	21
Figure 12: Typical Bioscrubber Schematic	21
Figure 13: Typical Biotrickling Filter Schematic	22
Figure 14: Vertical Bed Carbon Dry Media System.....	24
Figure 15: Horizontal Bed Carbon Dry Media System	25
Figure 16: Photoionization Unit Treating Headworks Building Odors.....	26
Figure 17 Proposed New Odor Control Treatment Equipment Locations	36

List of Tables

Table 1 Odor Treatment Unit at Thermophilic Equalization Tank.....	15
Table 2 Odor Treatment Unit at Digested Sludge Holding Tanks	15
Table 3 Odor Treatment Unit at Biosolids Building	17
Table 4 NFPA 820 Requirements	27
Table 5 Headworks Odor Treatment Design Summary	29
Table 6 Primary Treatment Odor Treatment Design Summary.....	30
Table 7 DAF Odor Treatment Design Summary.....	31
Table 8 Digesters Odor Treatment Design Summary	31
Table 9 Biosolids Building Odor Treatment Design Summary	32
Table 10 Headworks Wet Chemical Scrubber Design Criteria.....	32
Table 11 Digesters and DAF Wet Chemical Scrubber Design Criteria	33
Table 12 Digested Sludge Holding Tanks Wet Chemical Scrubber Design Criteria	34
Table 13 Biosolids Building Dry Media Scrubber Design Criteria	34

Executive Summary

This memorandum describes odor control and treatment planning for the Orem Water Reclamation Facility (OWRF). Location of OWRF with respect to the surrounding public areas, historical odor complaints, and wind rose to understand prevailing wind directions for odor dispersion were considered. The existing facilities namely headworks, primary treatment process, secondary treatment process, and solids handling facilities were evaluated for odor potential. The existing odor treatment systems were also evaluated with respect to size and condition.

Currently, the headworks building does not have odor containment and treatment. This area is a major source of odor emission which can be reduced by adding iron metal salts upstream of headworks and installing covers and an odor scrubber to capture and treat the odorous air.

The primary treatment process has not been causing odor nuisance and is not currently equipped with any odor containment or treatment systems. It may be beneficial in the future to cover the turbulent areas including launders and weirs.

The secondary treatment process has a very low potential for odor omission and doesn't require any improvements associated with odor control at this point.

The solids handling facility is a major source of odor emissions at OWRF. Besides hydrogen sulfide based odors, other odors of concern are ammonia and reduced sulfur compounds such as mercaptans. Currently, three different odor control units are installed at solids handling facilities., however, two out of the three units are at the end of their service life. The remaining third unit is deemed undersized to treat odor efficiently under the current operations mode. Thus, all three existing odor control units need replacement or upgrade.

To implement the suggested odor treatment plan, odor monitoring (in the form of short-term continuous hydrogen sulfide monitoring using devices offered by Acrulog or Thermofisher OdaLog) is recommended to aid in the design. A weather station should be installed at OWRF to confirm or negate whether odor events are emanating from OWRF or other facilities. Also, while implementing odor control upgrades that may have impact on buildings housing electrical and process equipment, the building HVAC system and NFPA classification building should be evaluated.

1. Introduction

This memorandum presents the odor assessment and odor control findings of the Orem Water Reclamation Facility (OWRF). Different process units and structures of OWRF will be analyzed for the potential of odor emissions and their control. OWRF staff inputs will be considered while developing the odor control findings.

2. Background

Municipal wastewaters are prone to generating noxious odors. Typically, these odors are attributed to hydrogen sulfide, which is primarily generated by converting wastewater dissolved sulfates and sulfites under anaerobic conditions to sulfide. In addition, the anaerobic decomposition of organic matter containing sulfur generates organic sulfur-based compounds such as mercaptans. Flow turbulence exacerbates the release of gas phase odors contained in wastewater flows.

Sulfur in the form of dissolved sulfates is commonly found in the potable water supply and domestic waste produced by households and sulfates along with sulfites can be produced in especially high quantities at restaurants and by certain industrial processes. Sulfate reducing bacteria located in the submerged biofilms of sewer piping and structures produce hydrogen sulfide from dissolved sulfates and sulfites. Hydrogen sulfide is commonly the primary constituent responsible for foul odors emitting from the sewers and sewage treatment facilities. Gas phase hydrogen sulfide generates a foul odor perceivable to humans at low concentrations (~1 ppm). Hydrogen sulfide generated in the sewer system can also migrate to the sewer system headspace causing corrosion under moist conditions. Hydrogen sulfide in the gas phase will be used by sulfur oxidizing bacteria that accumulate on moist crown areas of sewer piping and these microbes will convert the sulfides to sulfuric acid in the presence of oxygen. This sulfuric acid formation is very corrosive to concrete and uncoated metal piping.

Sludges and biosolids produced from the wastewater treatment process generate odor emissions in the form of hydrogen sulfide, ammonia, amines, and reduced sulfur compounds.

3. Facility Location

Figure 1 shows the location of OWRF and the surrounding residential, commercial, and industrial areas. On the north and north-west side of OWRF, residential areas are present while on the south and west side of OWRF commercial businesses and industrial areas are present. Any significant levels of noxious odors generated at OWRF may disperse to these surrounding areas and beyond depending on weather conditions and lead to potential odor complaints. Hence it is particularly important to contain significant odor sources at OWRF and treat them.

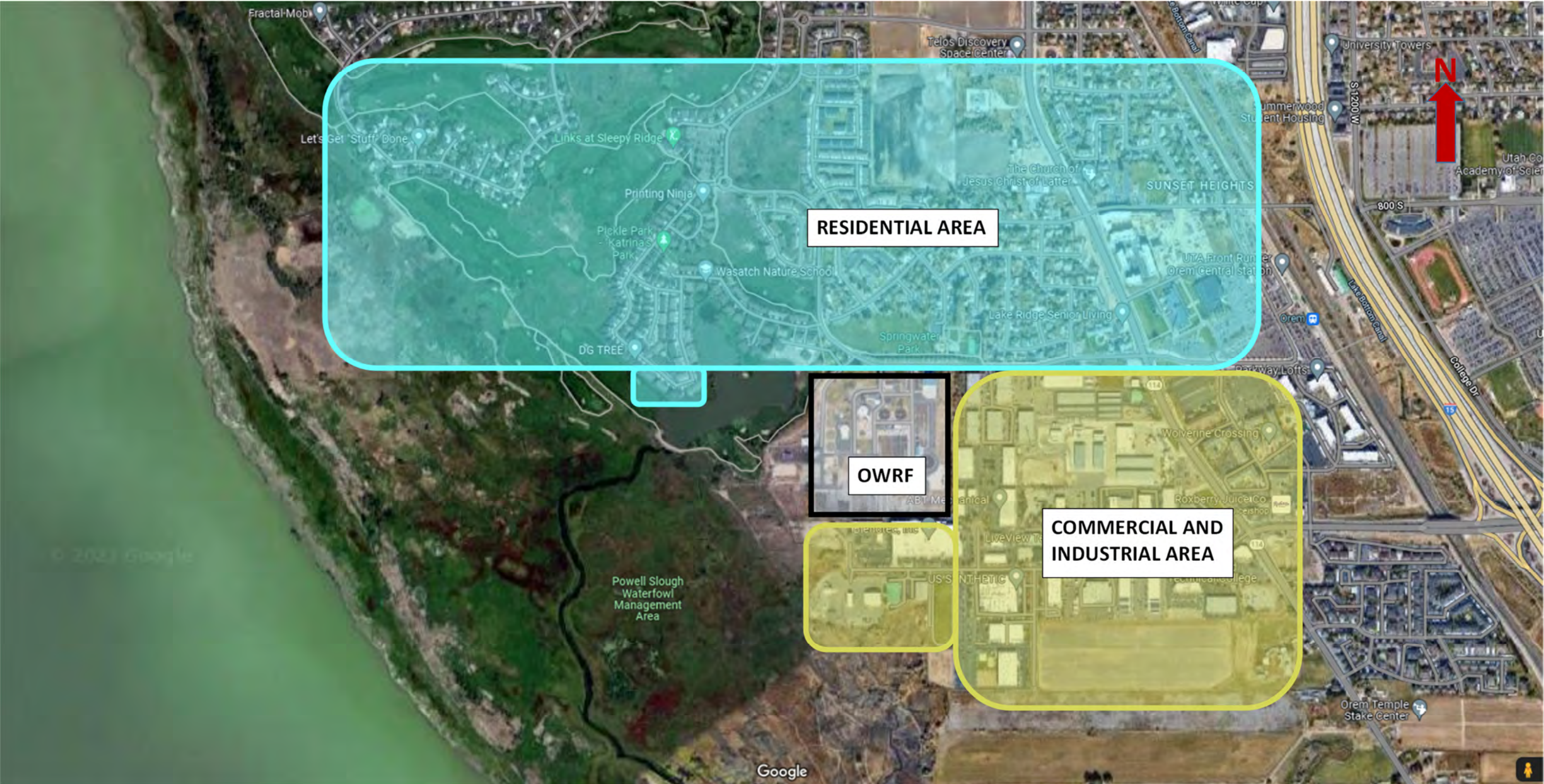


Figure 1: Map showing the location of Orem Water Reclamation Facility (OWRF)

4. Historical Odor complaints

OWRF staff mentioned that OWRF has received very few odor complaints in the past. There have been only three instances of odor complaints in the last four years. Figure 2 shows the locations of odor complaints. OWRF staff indicated that the complainants reside near Utah lake and the odor could have been from the lake. Additionally, wind may not have been blowing from OWRF toward the complainant's location, but OWRF staff does not have a weather station to assist in providing supporting information to confirm or contest these claims.



Figure 2 Location of Historical Odor Complaints

5. Wind Rose for Orem

The closest weather station near OWRF is located at Provo Municipal Airport, Provo, Utah. National Oceanic and Atmospheric Administration (NOAA) suggests using the Iowa Environmental Mesonet (IEM) website¹ for wind roses. Figure 3 shows the custom wind rose from January 2017 to December 2020 that was created from the IEM website.

¹ <https://mesonet.agron.iastate.edu/sites/locate.php>.



[PVU] PROVO MUNI (AWOS)

Windrose Plot [Time Domain: Jan 1 - Dec 31, 12 AM-11 PM]

Time Bounds: 01 Jan 2017 12:56 AM - 31 Dec 2020 10:56 PM America/Denver

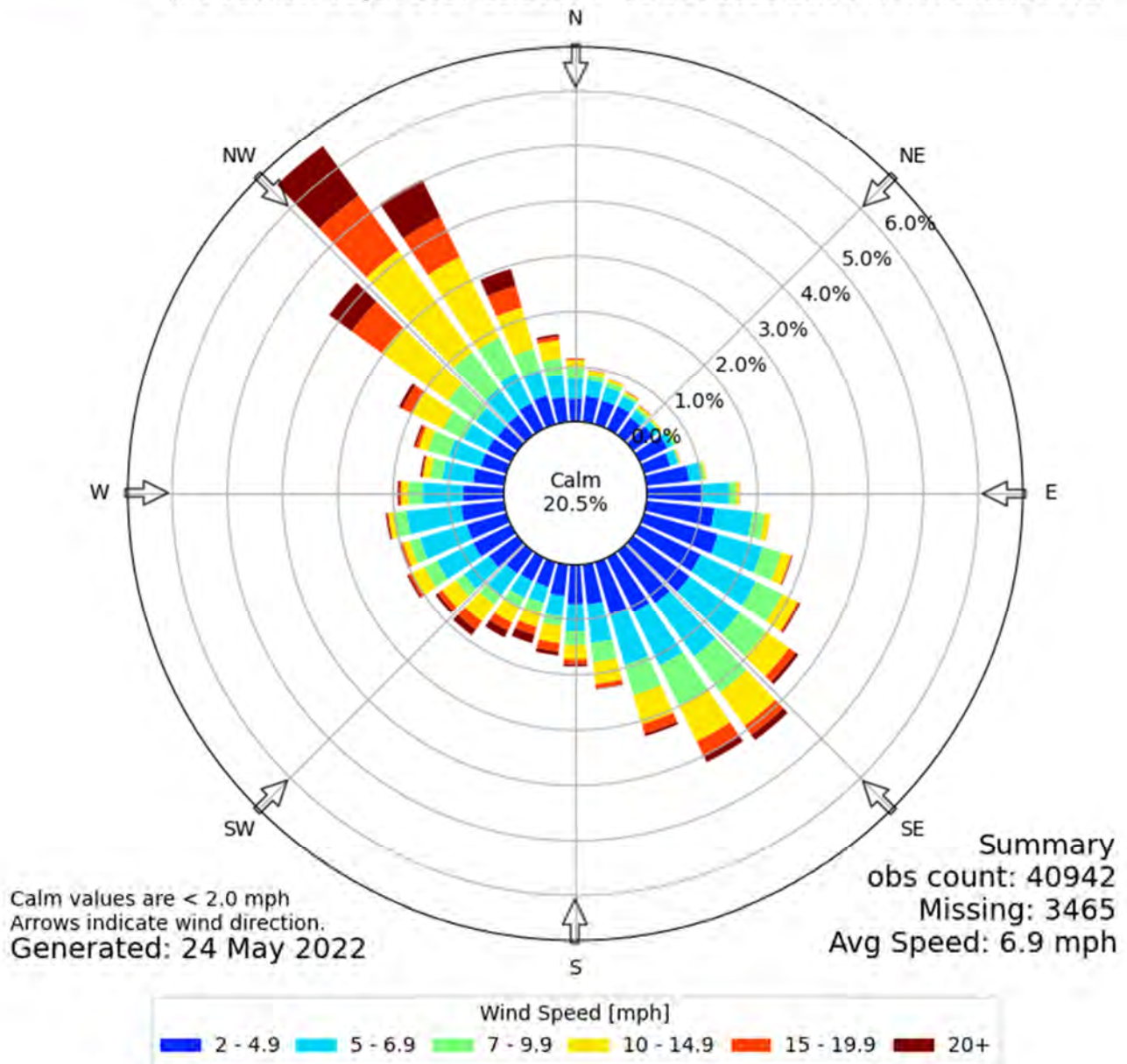


Figure 3: Wind Rose at Provo Municipal Airport from January 2017 to December 2020

It can be observed that most of the time, 20.5% of the time, the wind conditions are calm, indicating that odors created at OWRF have less chance of dispersion. However, other times, the wind blows the strongest from the north-west (approximately 6% time) and south-east (approximately 4% time) directions. Considering the location of OWRF, the wind blowing from a south-east direction will carry significant odor emissions from OWRF into the nearby residential areas and potentially cause odor complaints. At the same time, the wind blowing from the North-West side will carry odors from Utah lake to residential areas which residents may confuse with OWRF odors. The wind blowing from the

south-east side has wind speed primarily in the range of 2 to 6.9 mph and wind blowing from the north-west side has wind speed majorly in the range of 7 to 14.9 mph. Thus, chances of odor dispersion from Utah lake have a higher likelihood compared to odor from OWRF because of higher wind speed. This is the reason OWRF staff indicated that the odor complaints may be due to Utah lake as discussed in Section 4. The wind rose data from the Provo Municipal Airport is considered representative of wind conditions at OWRF as the distance between the two locations is approximately six miles. It is important to note that the wind rose at the Salt Lake City Airport provides similar wind data and the Provo and Salt Lake wind roses demonstrate the prevailing wind directions for this region in general.

6. Existing Facilities Odor Evaluation

This section will focus on the evaluation of facilities for odor emission and existing odor control measures at different facilities including headworks, primary treatment process, secondary treatment process, and solids handling facility.

6.1 Headworks

The headworks facility includes a Palmer Bowlus flume, mechanical step screens, aerated grit chamber, and screenings handling washer compactor unit.

The Palmer Bowlus flume resides in an influent channel outside of the headworks building. The Palmer Bowlus flume creates a hydraulic jump with significant turbulence. This turbulent flow facilitates odor release from the wastewater. The flume and its influent channel are not covered and open to the building headspace. The influent channel is receiving raw wastewater from the collection system and the significant release of odorous gases such as H_2S gas causes odor issues.

The three mechanical step screens, a screenings collection dumpster, and a grit classifier are installed inside the headworks building. The screen channels are covered with open grating instead of solid covers and allows the emission of the odorous gases from the channels into the building headspace. The screens are covered with stainless steel covers. The screenings collection dumpster is also open to the building headspace and is a source of significant odor emissions into the headworks building headspace. The grit classifier is covered but the grit dumpster is open to the building headspace. The headworks building does not have odor containment or treatment process.

A wall-mounted exhaust fan provides ventilation air exchanges of the building headspace by drawing fresh air via louvers into the building and exhausting building headspace air outside the building. The ventilation fan is used to reduce the accumulation of odorous and hazardous gases within the building. However, discharge of building headspace air into the facility atmosphere even under dilution with fresh intake air could be a source of odors for nearby public odor complaints.

The aerated grit unit is adjacent to the headworks building and open to the atmosphere. Aerated grit chambers have the potential of high odor emission because of high liquid turbulence².

² WEF MOP 8, Chapter 7, Table 7.15 Treatment Process Emission Summary



Figure 4: Headworks building with gratings on channels and covered equipment



Figure 5: Aerated grit unit open to the atmosphere

6.2 Primary Treatment Process

The primary treatment process includes a primary clarifier splitter box, distribution boxes, primary clarifiers, screw pump station, and mixed flow pump station.

The primary clarifier splitter box is not covered which could be a source of potential odor emissions as it is handling raw wastewater which has not gone through any treatment. However, the surface area of the splitter box is insignificant compared to the grit chamber or primary clarifiers. The primary clarifier distribution box no. 1 and primary clarifier distribution box no. 2 are not covered. Covers may be added to contain any odor emissions from these areas although odors may migrate downstream to other open areas.

There are four 75 ft diameter primary clarifiers at the site which are open to the atmosphere. The quiescent large area of the primary clarifiers can have minimal odor emissions but the turbulence at the clarifier discharge weirs is usually the largest generator of odors from a primary clarifier. There is a 1.4 to 3.4 ft of drop between the v-notch weir and water surface in the launders which can be turbulent and has the potential to release odors.

Primary effluent is pumped to the bioreactors by the mixed flow pump station and the screw pump station. OWRf staff mentioned that the mixed flow pump station is used most of the time and the screw pump station is rarely used. The screw pump station is open to the atmosphere and the operation mechanism of the screw pumps induces substantial turbulence and releases odors. The mixed flow pump-station wet wells are covered with aluminum grating which allows emission of the odor from the wet well to atmosphere as it is handling raw wastewater.



Figure 6: Primary clarifier open to the atmosphere

It has been noted that since the screw pumps are not used on a regular basis, odor emission from the primary area is minimal.

6.3 Secondary Treatment Process

OWRF secondary treatment process includes three bioreactors, two 95 ft diameter secondary clarifiers, and two 120 ft diameter secondary clarifiers.

Each bioreactor is designed for biological nutrient removal and consists of an anaerobic zone, anoxic zone, and aeration zone. Except for the anaerobic and anoxic zone, little or no hydrogen sulfide is observed at bioreactors. The aeration mechanism in the aeration zone affects emission by changing gas to liquid ratio causing excessive air stripping and releasing more odors if there are any odorous compounds. However, due to the abundance of oxygen as an electron acceptor the reduction of sulfur compounds to hydrogen sulfide is reduced and negligible odor is observed at aeration zones. In the anoxic zones, denitrifying (nitrite and nitrate reducing) bacteria are more prevalent, and the activity of sulfur-reducing bacteria is reduced or almost absent. In anaerobic zones, if hydraulic retention time (HRT) is more than required for hydrolysis then the chances of production of H_2S increase because of acidogenesis. However anaerobic zones are typically sized for the removal of phosphorous by

conditioning phosphorous accumulating organisms (PAOs) thus HRT and other design conditions prohibit acidogenesis activity. Thus, little or no hydrogen sulfide is observed at bioreactors.

The wastewater received at the secondary clarifiers has already been treated biologically and the water has oxygen levels that inhibit sulfur reduction; thus, concentrations of odorous compounds are very low. As a result, odor containment is typically not required at secondary clarifiers even though the surface area is comparatively large.

The secondary treatment process at OWRF does not have any odor containment or treatment process.



Figure 7: Anaerobic basins with cannon air mixer

6.4 Solids Handling Facility

Solids handling facility includes dissolved air flotation (DAF) thickener, thermophilic equalization tank, one thermophilic digester, a plug flow reactor, two mesophilic digesters, two sludge storage tanks, a biosolids building, and solids drying beds.

DAF is used to thicken the waste activated sludge (WAS). WAS is a settled solid from the secondary clarifiers that have gone through aerobic treatment. Thus, the potential for odor emissions at DAF is expected to be minimal if the secondary process is operating properly and only WAS sludge is being

processed. The DAF could be a potential source of odor in the future if WAS is co-thickened with Primary Sludge as the released flotation air bubbles will strip any odors out of the DAF liquid phase if present.



Figure 8: Dissolved Air Flotation (DAF) thickener open to the atmosphere

The thermophilic equalization tank receives primary sludge and thickened WAS from DAF. The equalization basin which is holding thickened solids becomes increasingly anaerobic with retention time and generates odors. Also, because of thickened solids, the concentration of odorous compounds is extremely high. The thermophilic equalization tank is equipped with photoionization equipment for odor treatment. Table 1 summarizes details of the installed photoionization unit. However, OWRF staff has mentioned that they are operating the thermophilic equalization tank with reduced capacity to maintain low solids depth in the tank. The higher solids depth in tanks generates very strong odors. The photoionization process removes all odor sources, and it is deemed that the photoionization unit is undersized for current operations (operating at lower EQ basin levels than design) and requires upgrades. Note that the photoionization lamps should be inspected monthly and spent lamps changed out as needed. Also, the Photoionization catalyst media has a reduced life under high odor concentrations and would need to be replaced every 2 to 3 years.

Table 1 Odor Treatment Unit at Thermophilic Equalization Tank

Description	Value
Source of Off-Gas	Thermophilic Equalization Tank
Technology	Neutralox Photoionization
Manufacturer	Ambio Biofiltration Ltd.
Installation Year	2011
Number of Units	1
Odorous Gas Concentration	Not specified (Sulfur based)
Air Flow Rate	60 to 90 cfm
Power	1.1 hp

The flowrate stated in the table above indicates that the existing unit provides minimal air changes (< 1/hr) which may be the cause of odorous events in conjunction with the possibility that the compounds generated at the thermophilic equalization tank are not treatable by the photoionization process.

The thermophilic digester and mesophilic digesters treat solids anaerobically at higher SRT. Thus, they generate high concentrations of odorous compounds. But the thermophilic digester and mesophilic digesters are covered so they contain odors and do not cause any odor issues. Also, methane generated from the digesters is flared off thus the potential for methane gas odor is reduced. However, OWRF staff mentioned that the valves on the lid can malfunction and there is a chance of release of methane and H₂S from digesters.

The sludge holding tanks are receiving anaerobically digested sludge, thus there is a high potential for odor emissions. The solids holding tanks were formerly used as aerobic digesters. The solids held in these tanks are either aerated continuously or aerated periodically under a timed schedule. The aeration of the digested sludge creates a high potential for concentrated odor emissions. The digested sludge holding tanks are covered to contain the odors.

The sludge holding tanks are equipped with a chemical scrubber system for odor control and treatment. Table 2 summarizes details of the installed chemical scrubber unit. However, the unit is 24 years old and near its end of life. OWRF staff has indicated that the unit needs to be refurbished or replaced with in-kind technology.

Table 2 Odor Treatment Unit at Digested Sludge Holding Tanks

Description	Value
Source of Off-Gas	Aeration of anaerobically digested sludge
Technology	Chemical Scrubber
Manufacturer	U.S. Filter Environmental
Installation Year	1998
Number of Units	1
Odorous Gas Concentration	10 to 25 ppm H ₂ S
Air Flow Rate	7,400 cfm
Number of Stages	3

Description	Value
Chemicals Used	NaOCl (Sodium Hypochlorite) + NaOH (Sodium Hydroxide)
Minimum Removal Efficiency	99.00%
Packing Media	Plastic Media by Lanpac



Figure 9: Chemical Scrubber unit for sludge holding tanks (right) and dewatering building (left)

The biosolids building contains two belt press solids dewatering units and a conveyor belt to convey dewatered solids to a truck loadout bay. The existing solids dewatering units are equipped with fume

hoods to contain odors released from the operating units and surrounding area and are sent to the odor scrubber unit for treatment. OWRF is currently implementing a dewatering system rehabilitation project. This memorandum will not evaluate changes to the dewatering equipment odor collection hoods as rehabilitation design documents are not yet available for review. The biosolids building is equipped with a chemical odor scrubber unit and Table 3 summarizes the details of the unit. However, the unit is 28 years old and near its end of life. OWRF staff has indicated that the unit needs to be refurbished or replaced or new improved technology will be required.

Table 3 Odor Treatment Unit at Biosolids Building

Description	Value
Source of Off-Gas	Biosolids Building
Technology	Chemical Scrubber
Manufacturer	RJ Environmental, Inc.
Installation Year	1994
Number of Units	1
Odorous Gas Concentration	30 ppm H ₂ S
Air Flow Rate	8,250 to 16,500 cfm
Number of Stages	1
Chemicals Used	NaOCl (Sodium Hypochlorite) + NaOH (Sodium Hydroxide)
Minimum Removal Efficiency	99.00%
Packing Media	Plastic Media by Lanpac



Figure 10: Odor collection hoods over dewatering equipment in Biosolids Building

OWRF facility has eight solids drying beds where dewatered solids are stored. There is no odor treatment employed at the solids drying beds.

7. Odor Treatment Technologies

This section discusses select odor treatment technologies. Subsequently, different odor treatment measures such as chemical addition at source, odor containment, and treatment with select technologies will be discussed for different facilities of OWRF based on the odor evaluation discussed in Section 6.

7.1 Chemical Feed

Different chemical oxidizers or salts can be added to wastewater to reduce sulfide and non-sulfide related odors. Chemical oxidants oxidize organic based odorous compounds and convert sulfide to sulfate or elemental sulfur, depending on pH, through oxidation-reduction reactions. These reactions reduce the concentration of dissolved H_2S that can transfer to the gas phase. Commonly used oxidants include chlorine, hydrogen peroxide, and less commonly, potassium permanganate and ozone. Ozone has been successfully applied in collection system applications for odor and grease control in sewage lift stations.

Other chemicals, such as iron salts, can be dosed to wastewater or sludge solids to specifically bind with dissolved sulfides and create a precipitate or increase the pH to prevent sulfide release and reduce odor

generation due to biological activity. Potential chemical feed technologies applicable to OWRF are discussed in more detail below.

7.1.1. Chlorine Addition

Chlorine is commonly dosed into wastewater to control odors. Typically, chlorine is dosed into the wastewater in the form of liquid sodium hypochlorite. The dosed hypochlorite reacts with sulfides and any other organics present in the wastewater through oxidation reactions. Chlorine doses needed to control odors can become excessive as chlorine reacts with other organic compounds present in wastewater in addition to sulfides.

7.1.2. Iron Salts

Typically, iron salts are added into wastewater using acidic ferrous chloride or ferric chloride solutions. The iron binds with the dissolved sulfide present and forms a precipitate, preventing the sulfide from moving into the gas phase and causing odors. Iron salt dosages are based on the sulfide present and one disadvantage of iron salt dosing for odor control is that it does not react with other organic compound-based odors (mercaptans). Iron salts target the removal of dissolved sulfides and can also benefit processes to control sulfide formation such as anaerobic digesters.

Other iron salt such as ferrous sulfate and ferric sulfate can be a substitute for ferrous or ferric chloride, however, sulfate-based salts have been questioned because sulfate can be reduced to sulfide. This typically is not a concern in municipal wastewater systems, because sulfate typically is present in excess, and sulfide generation is not increased significantly³. However, in areas of localized pH depression, such as anaerobic waste streams in which the pH drops below 6.5, ferrous sulfide partially dissociates and may release sulfide into the wastewater. Thus, the use of ferrous chloride or ferric chloride is recommended for odor control.

It is difficult to estimate the dose of required iron metal salt as it is influenced by many factors. Thus, a pilot test with an initial dose rate as per stoichiometric requirements should be conducted to calculate dose requirements and annual chemical consumption. Iron metal salts react with dissolved sulfide as per the following reactions:



Adding iron salts at OWRF can present multiple benefits in addition to odor control including phosphorous reduction and struvite control. Iron salt reacts with phosphate to precipitate iron phosphate. It also binds with struvite forming chemicals to alter the stoichiometry needed to form struvite and prevent its formation.

Incidental disadvantages of iron salt addition include increased overall solid production, the potential impact on UV lamp performance, and visible staining of structures with a reddish color.

Other metal salts, such as chromium, copper, and zinc, react with sulfide, but these are regulated heavy metals. High heavy-metal concentrations make biosolids hazardous and disposal difficult and costly.

³ WEF MOP 8, Chapter 7, Section 7.1 Liquid-Phase Treatment

7.1.3. pH Increaseers

pH can be increased using such chemicals as magnesium hydroxide or lime. Magnesium hydroxide due to buffering effects can safely raise pH into the 8 to 9 range to lock a significant amount of sulfide in the liquid phase and thereby minimizing odor release. However significant magnesium hydroxide doses may be required to maintain the pH between 8 and 9. Manufactured lime or slaked lime can be used to control odors, especially in digested sludge solids but is now used for sulfide odor control in wastewater as well. Manufactured lime is used more in the collection system or in sludge solids where elevated pH levels above 9 can be tolerated. Lime dosing around the activated sludge process is not practiced due to the risk of high pH levels impacting the activated sludge process.

7.2 Foul Air Treatment

Odor mitigation in the liquid phase may not be feasible under specific instances. Foul air phase containment and treatment are required in various locations such as wastewater lift stations, headworks buildings, and biosolids facilities. Various applicable foul air treatment technologies for the OWRF facility are discussed below.

7.2.1. Wet Chemical Scrubbers

Chemical scrubber systems employ two or more stages of chemical treatment to remove a wide array of odors from wastewater sources. The scrubber system uses media that provides a high surface area to allow the exchange between the foul air and the treatment solution. In the first stage, sodium hydroxide is injected into the spray water to raise its pH which transfers the air phase sulfides to the liquid phase. Chlorine is injected in the second stage spray solution to oxidize the organic compounds. The chemical scrubbers offer effective physio-chemical treatment of odor and reliable efficiency. But major challenges with this technology include the high cost of chemical usage and media scaling due to the high pH and TDS conditions. This requires frequent scrubber acid washing. Example manufacturers of Wet Chemical Scrubbers include:

- ECS
- Ecoverde
- Evoqua
- CECO Environmental HEE-Duall



Figure 11: Typical Low-Profile Wet Chemical Scrubber for Odorous Air Treatment

As discussed earlier, OWRF uses two different wet chemical scrubbers at the sludge storage tanks and biosolids building, but they are at the end of their useful life.

7.2.2. Biotrickling Filters and Bioscrubbers

Biotrickling filters and bioscrubbers work similarly in that they use microorganisms and synthetic media packing for organisms to form biofilm on and in water. Odorous or polluted air is collected and forced up through structured media within the vessel. In biotrickling filters, the microorganisms grow primarily on the media.

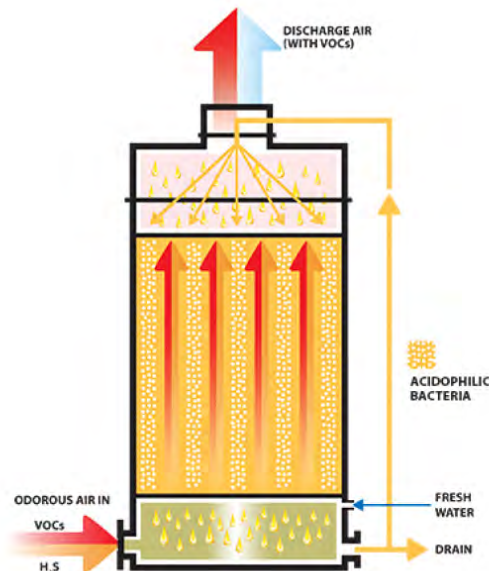


Figure 12: Typical Bioscrubber Schematic

Bioscrubber odor and emission treatment systems rely primarily on microorganisms present in the water that is recirculated through the treatment vessel. Foul air is forced upward through the bottom of the

vessel. On its way up, it is dispersed through synthetic media and contacts the water laden with microorganisms. The microorganisms metabolize the offending compounds, leaving clean air to be released from the vessel. Water recirculation is the key feature of bioscrubbers. The water retains all the metabolized compounds removed from the air, increasing its acidity. While that acidity supports the growth of some microorganisms, not all types can thrive in the acidic environment.

The key differentiator for biotrickling filters compared to bioscrubbers is that they do not recirculate water and a neutral pH (near the top) to acidic pH (near the bottom) is maintained across the filter packing, but this varies manufacturer to manufacturer. Some manufacturers allow the bottom portions of their biotrickling filters to go fully acidic. The water used in these systems passes through only once and acts as a rinse to drain the metabolized compounds away. Despite not employing internal water recirculation, biotrickling filters can have similar water usage rates compared to bioscrubbers.

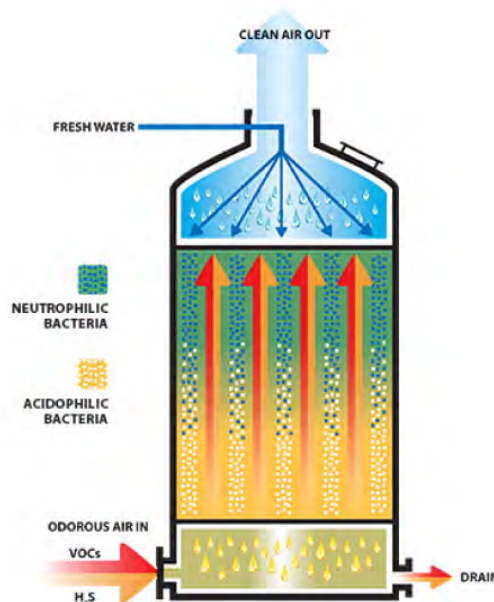


Figure 13: Typical Biotrickling Filter Schematic

Biotrickling filters and bioscrubber systems can be fitted with integrated dry media scrubbing trays to provide an additional odorous air treatment polishing step and to provide a backup treatment to the biological removal process during startup or biological upset events.

Biotrickling and bioscrubbers require supplemental nutrient feed and water supply to maintain biological growth.

Example manufacturers of Biotrickling or Bioscrubber Odorous Air Treatment Systems include:

- BioAir – Ecofilter (single stage) and Ecopure (two stage biotrickling filter)
- ECS
- Ecoverde

Being a biological system, the biotrickling filters and bioscrubbers are susceptible to process fluctuations and require a longer acclimation period at start up. However, it is a greener technology which requires less chemical usage, and lower O&M (operation and maintenance) costs while providing efficient odor removal.

7.2.3. Adsorption Systems – Carbon

Activated carbon (AC) has been used to control odors for over 100 years. AC is typically made by thermal decomposition of high-carbon content materials such as coal, wood, peat, or coconut shells. Presently, both AC and specialized media are used to remove odors from the air using a naturally occurring phenomenon called adsorption, in which molecules in the air stream are trapped by cavities in the media's surface (both internally and externally). The performance of the media will vary based on the surface area, pore size, and oxidation properties. The main design factor for dry adsorption systems is the media face velocity, which is also a function of bed residence time. Dry adsorption systems are best suited for low loading rates. Thus, carbon and dry media scrubber units are provided to polish treated air from chemical scrubbers, and biological based biofilters and biotrickling / bioscrubbers. Carbon dry media units can also be used on their own when odor concentrations are low. In addition, carbon-based media units can be packed with alternate dry media including permanganate impregnated alumina. Media units can be configured as a vertical unit with two media trays mounted above each other or in a horizontal configuration with media beds mounted side by side to improve media bed access for replacement. Horizontal based carbon units are favored for installation for odorous air flows greater than 5,000 cfm and when multimedia beds are employed (e.g., carbon with alumina). Radial flow carbon units can be employed for higher airflows in tighter footprints. Example manufacturers of Carbon and Dry Media Scrubbers include:

- ECS
- Ecoverde

- Evoqua



Figure 14: Vertical Bed Carbon Dry Media System



Figure 15: Horizontal Bed Carbon Dry Media System

Adsorption systems are easy to operate and maintain and do not require continuous feed of chemicals, water, or nutrient. However, the media requires periodic replacements which increases O&M costs. Carbon can remove sulfides and other organic based odorous compounds. One limitation of Activated Carbon scrubbers is moisture. Under these conditions, the media will plug and reduce the hydraulic and adsorption capacity of the media.

7.2.4. Photoionization

Photoionization is based on the application of UV light to odorous air and passing the UV light dosed air through a catalyst. The first part of the process mimics natural reactions that take place in the upper atmosphere by the interaction of air and UV light coming from the sun. The principles are straightforward. Odorous air passes through a chamber where it is exposed to intense UV light using corona discharge. The UV light creates free radicals, (O^- , OH^- , O_3 , etc.), that immediately begin oxidizing the odor-causing compounds.

The UV light treated air then passes to a catalyst, where any remaining odorous compounds are adsorbed and broken down by the constant flow of free radicals coming from the UV section. The reactions that take place also indicate catalytic activity as one of the by-products is native sulfur – the classic catalytic Claus reaction. Thus, the catalyst acts as both a catalyst and buffer.

The sole manufacturer of the UV Photoionization Equipment is Neutralox Umwelttechnik GmbH, with a US Subsidiary, Nuetradox, Inc. in Chicago, IL to provide parts and services for its installations across the

United States. The Nuetralox equipment is represented in North America by Ambio Biofiltration Ltd., a company based in Ontario, Canada.

The Nuetralox technology has been widely used in Europe for wastewater related odor control for over 20 years. Because this technology is established and has successful wastewater odor control installations in the United States it should be taken under consideration for future OWRF odor control projects. A Nuetralox photoionization unit is currently employed at the OWRF sludge EQ Tank, but this unit is deemed undersized for the current operation mode of the EQ Tank.

Photoionization can oxidize a wide variety of odorous compounds and requires low maintenance. They do not need a continuous feed of chemicals, water, or nutrient but these systems do require UV lamp and catalyst media replacements. These replacements can be accomplished rapidly with little down time for the units.



Figure 16: Photoionization Unit Treating Headworks Building Odors

8. NFPA Considerations

Odorous areas present safety hazards for the facility staff and adjacent areas. The National Electric Code NFPA 820 is developed to provide recommendations that are intended to mitigate and reduce these hazards. It is recommended when devising odor control systems to concurrently evaluate the impacts of the NFPA code since it dictates the air changes required which impacts the size of the odor control conveyance and treatment systems.

It is recommended that NFPA requirements should be considered for buildings and process tanks where future odor control upgrades are to be conducted. Any upgrades to the HVAC systems of the building may require reclassification of the building. Table 4 summarizes NFPA requirements that may be applicable to OWRF.

Table 4 NFPA 820 Requirements

Area	Fire/ Explosion Hazard	Ventilation	Extent of Classified Area	NEC Area Elect. Classification	Materials of Construction	Fire Protection Measures
Coarse and Fine Screen Facilities	Possible ignition of flammable gases and floating flammable liquids	< 12 air changes/ hr	Enclosed – entire space	Div. 1	Non-combustible material	Potable fire extinguisher, hydrant protection, combustible gas detection system
		12 air changes/ hr	Enclosed – entire space	Div. 2	Non-combustible, limited-combustible, or low flame spread index material	
Grit Removal Tanks	Possible ignition of flammable gases and floating flammable liquids	Not enclosed, open to atm.	Within a 10 ft envelope	Div. 2	Non-combustible, limited-combustible, or low flame spread index material	Potable fire extinguisher, hydrant protection
Primary Sedimentation Tanks	Possible ignition of flammable gases and floating flammable liquids	Not enclosed, open to atm.	Interior of tank from min operating water surface to top of tank wall, envelope 18" above top of tank and extend 18" beyond exterior wall, envelope 18" above existing grade extending 10 ft horizontally from exterior of tank wall	Div. 2	Non-combustible, limited-combustible, or low flame spread index material	Hydrant protection
Intermediate, Secondary, or Tertiary Sed Basins	N/A	Not Required	N/A	Classified (see Primary Sed), Unclassified if preceded by Primary Sed	Not Required	Hydrant protection
Effluent Structures	N/A	Not Required	N/A	Unclassified	Not Required	Hydrant protection
Coarse and Fine Screenings Handling Buildings	N/A	Not Required	N/A	Unclassified	Non-combustible, limited-combustible, or low flame spread index material	Hydrant protection, portable fire extinguisher, fire alarm system

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Area	Fire/ Explosion Hazard	Ventilation	Extent of Classified Area	NEC Area Elect. Classification	Materials of Construction	Fire Protection Measures
Grit-Handling Building	N/A	Not Required	N/A	Unclassified	Non-combustible, limited-combustible, or low flame spread index material	Hydrant protection, portable fire extinguisher, fire alarm system
Sludge Storage Wet Wells, Pits, and Holding Tanks	Possible generation of methane gas in explosive concentrations; carryover of floating flammable liquids	< 12 air changes/ hr	Enclosed – entire space	Div 1	Non-combustible material	Combustible gas detection system, hydrant protection, and portable fire extinguisher if tank enclosed in building
		12 air changes/ hr	Enclosed – entire space	Div 2	Non-combustible, limited-combustible, or low flame spread index material	
		Not enclosed, open to atm.	Envelope of 18in above water surface and 10ft horizontally from wetted walls	Div 2	Non-combustible, limited-combustible, or low flame spread index material	Not Required

NFPA classification is highly dependent on the number of air changes which translates to air flow conveyed to the odor treatment systems and handled by the heating and cooling systems. This has a direct impact on the sizing of these units.

9. Odor Improvements Recommendations

9.1 Headworks

Two alternatives are proposed for odor treatment at the headworks.

9.1.1. Alternative 1: Cover and Treatment

As discussed in Section 6.1, many of the channels are covered with grating which does not provide any odor containment. It is recommended to place removable covers over channels and open bins containing collected grit or screenings and install ductwork for conveying odor to a chemical odor scrubber. The screen equipment and grit classifiers are enclosed.

Positive ventilation should be implemented by providing a fan to draw the foul air from the covered channels and maintaining a negative pressure in the covered channel headspace to minimize odorous air escaping into the equipment space. Makeup air can be provided using air intakes, strategically located to provide positive air movement in the headspace.

Wet chemical scrubbers are suggested at the headworks as chemical treatment provides a more reliable and responsive treatment. Table 5 summarizes the airflow required for odor treatment. Additionally, HVAC at the headworks building will need to be reevaluated.

Table 5 Headworks Odor Treatment Design Summary

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Suggested Treatment Technology	Required Removal
			Min./Avg./Max. H2S (ppm)		
Palmer Bowlus Flume	6	50	10/50/100	Wet Chemical Scrubber	>99% H2S
Under Headworks Channel Covers	6	100	10/50/100		
Headworks Room (Above channel grating)	12	4250 ¹ /5300 ²	10/50/100		
Aerated Grit ³	6	350	10/50/100		
1- Assuming 80% of headspace above channel grating (20% of headspace is occupied by equipment, structural elements, etc.) 2- Assuming 100% of headspace above channel grating 3- Odor containment and treatment should be decided based on a sampling study					

9.1.2. Alternative 2: Chemical Addition Upstream of Headworks

Iron metal salts such as ferrous chloride, ferric chloride, ferrous sulfate, and ferric sulfate can be added upstream of headworks to precipitate dissolved sulfide and reduce odor. Space for a tank and pump are being allocated in the chemical storage area being constructed as part of the Reuse Project. In the future, a tank and transfer pipe to headworks could be installed. Using optimal dosing, the dissolved sulfide concentration can be reduced below the threshold value for odor. This is expected to reduce odor generation from the headworks facility and may result in reducing the operating cost of the wet chemical scrubber.

It is difficult to estimate the dose of required iron metal salt as it is influenced by many factors. Thus, a pilot test with an initial dose rate as per stoichiometric requirements should be conducted to calculate dose requirements and annual chemical consumption.

9.2 Primary Treatment Process

The primary treatment process and conveying units include a splitter box, primary clarifiers, and the mixed flow pump station. Improvements associated with odor control are not recommended at this stage since the primary treatment area has not been a source of odors.

For future consideration, in case odors present an issue, it may be beneficial to cover the primary clarifier splitter box, the weirs and launders and the mixed flow pump station wetwells.

Covering all of the clarifier's weirs and launders only versus the full basin area is expected to considerably reduce the cost of the cover system. Considering 6 air changes per hour, an air flow rate of 3,650 scfm will be required if the complete surface area of the clarifiers is covered while an air flow rate of 1,130 scfm will be required if only weirs and launders are covered.

Table 6 summarizes the design parameters associated with this structure.

Table 6 Primary Treatment Odor Treatment Design Summary

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Suggested Treatment Technology	Required Removal
			Min./Avg./Max. H ₂ S (ppm)		
Splitter Box	6	100	10/50/100	Wet Chemical Scrubber	>99% H ₂ S
All Primary Clarifiers Weir and Launders	6	1,150	10/50/100		
Bioreactor Pump Station Wet Wells	6	50	10/50/100	Carbon and Dry Media Scrubbers	

9.3 Secondary Treatment Process

The secondary treatment process at OWRP does not have the potential for considerable odor nuisance. As long as the secondary treatment activated sludge and secondary clarification processes are being operated efficiently, odor treatment at the secondary treatment process is not required.

9.4 Solids Handling Facilities

9.4.1. DAF

Currently, DAF is not covered and does not have an odor control unit. However, there is a potential for odor emissions from the DAF as it is handling WAS. If WAS goes into anaerobic conditions, then it can lead to odor emissions. With proper DAF operation and continued processing of only WAS, it is recommended that DAF not be provided with odor containment or treatment at this time.

In the future, if the DAF is used to co-thicken primary settled solids along with WAS then installing solid covers and treating the contained odors is recommended. Primary settled solids have a high potential for odor emissions. So, solid covers and odor treatment are recommended if co-thickening of primary settled solids and WAS is expected at DAF. Table 7 summarizes odor treatment design requirements for DAF.

Table 7 DAF Odor Treatment Design Summary

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Suggested Treatment Technology	Required Removal
			Min./Avg./Max. H ₂ S (ppm)		
DAF	6	450 ¹	20/75/150	Wet Chemical Scrubbers	>99% H ₂ S
1- Assuming 3 feet of headspace under the DAF cover system.					

9.4.2. Digesters

The Thermophilic equalization tank and the sludge holding tanks headspaces are major sources of odor at the OWRF facility. Each of these locations are equipped with ductwork to convey the foul air to an odor treatment area as described earlier in Section 6.4. The wet scrubber odor treatment unit serving the sludge holding tanks is nearing the end of its service life and the Photoionization odor control unit serving the Thermophilic EQ is deemed undersized for the current operation configuration of the EQ tank (operating EQ tank at a lower level than designed).

It is recommended to replace the existing wet chemical scrubber at the sludge holding tanks and replace the undersized photoionization unit treating the Thermophilic EQ tank odors. This can be accomplished by providing a new wet chemical scrubber unit that is also sized to receive odorous air from the nearby DAF unit. Another alternative is to provide one wet chemical scrubber unit to process the EQ tank foul air and another wet chemical scrubber unit to process odorous air from the DAF. Table 8 summarizes the criteria for designing the treatment units at the digester and digested sludge storage tank areas.

Table 8 Digesters Odor Treatment Design Summary

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Suggested Treatment Technology	Required Removal
			Min./Avg./Max. H2S (ppm)		
Thermophilic Equalization Tank	6	650 ¹	20/75/150	Wet Chemical Scrubbers	>99% H2S
Sludge Holding Tanks	12	10,200 ²	5/25/50		
1 - Assuming only one-foot solids depth in tank resembling current operating conditions					
2 - Assuming both units are in operation with 15ft tall cover					

9.4.3. Biosolids Building

The biosolids building is another potential source of odors. The wet chemical scrubber equipment serving this facility is nearing the end of its useful life and should be replaced. Table 9 summarizes the criteria for designing the biosolids building wet chemical scrubber. Additionally, it is recommended that the HVAC system at the biosolids building be reevaluated for airflow balancing and area air conditioning needs.

Table 9 Biosolids Building Odor Treatment Design Summary

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Suggested Treatment Technology	Required Removal
			Min./Avg./Max. H ₂ S (ppm)		
Biosolids Building	12	16,400 ¹ /20,500 ²	1/5/10	Wet Chemical Scrubbers	>99% H ₂ S
1- Assuming 80% of headspace (20% of headspace is occupied by equipment, structural elements, etc.)					
2- Assuming 100% of headspace					

9.4.4. Sludge Drying Beds

Another potential source of odors is the holding of dewatered sludge, digested sludge in the OWRF drying beds. If odor complaints become of concern regarding this activity, manufactured lime slurry products such as Ultralime (manufactured by ASI) could be dosed in the digested sludge as it is being dewatered or held in the sludge holding tanks. Manufactured lime products are much more stable than slaked lime slurry and are not impacted by slurry caking and dusting that are challenges for slaked lime systems. The elevated pH in the sludge solids will lock in sulfide odors and halt biological activity as the solids are being dried. Of course, the sludge solids pH will be attenuated if the sludge solids are contacted by significant rainfall, but this option could be employed especially during dry periods if dewatered sludge solids odors become an issue.

Collection system debris from wet well and sewer line cleaning is collected by vacuum trucks and is also placed in a sludge drying bed. This collection system debris is a significant source of odors around the sludge drying bed area. It is recommended that this debris be processed through a septage pretreatment type facility (to remove large debris such as rocks and FOG) and then processed through the Headworks rather than being placed directly in the sludge drying beds.

10. Summary of Improvements

The recommended improvements associated with the odor mitigation at the OWRF include the following:

10.1 Headworks Wet Chemical Scrubber

It is recommended that a wet chemical scrubber unit be provided at this time to treat odoriferous air emissions at the Headworks. The design parameters associated with the headworks are outlined in Table 10 below:

Table 10 Headworks Wet Chemical Scrubber Design Criteria

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Required Removal
			Min./Avg./Max. H ₂ S (ppm)	
Palmer Bowlus Flume	6	50	10/50/100	>99% H ₂ S
Under Headworks Channel Covers	6	100		
Headworks Room (Above channel grating)	12	5,300		
Aerated Grit ³	6	350		
Total Flow (cfm)		5,800		

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Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Required Removal
			Min./Avg./Max. H2S (ppm)	
Wet Chemical Scrubber Configuration	Dual Stage Scrubber with Caustic and Hypochlorite Stages			
Scrubber Odorous Air Fan Materials of Construction	FRP			

In addition, OWRf may initiate iron salt based chemical feed upstream of the headworks to reduce odor levels to be treated in the new Headworks odor control system.

10.2 Primary Treatment Area

Odor improvements are not recommended for this area. A separate odor control scrubber may be considered in the future if the primary system odors become of concern to the nearby public and commercial receptors.

10.3 Digesters and DAF Area Wet Chemical Scrubber

It is proposed that the Thermophilic Digester and DAF areas be equipped with a new wet chemical scrubber that can also process odorous air collected from the DAF, (in case the DAF is used to co-thicken primary sludge and WAS in the future) and from the Thermophilic EQ Tank. The design parameters for Digester and DAF Area wet chemical Scrubber are outlined in Table 11 below:

Table 11 Digesters and DAF Wet Chemical Scrubber Design Criteria

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Required Removal
			Min./Avg./Max. H2S (ppm)	
DAF	6	450 ¹	20/75/150	>99% H2S
Thermophilic Equalization Tank	6	650	20/75/150	
Total Flow (cfm)	1,100			
Wet Chemical Scrubber Configuration	Dual Stage Scrubber with Caustic and Hypochlorite Stages			
Scrubber Odorous Air Fan Materials of Construction	FRP			
1- Assuming 3 feet of headspace under DAF cover system.				

10.4 Sludge Holding Tanks

It is recommended that the existing sludge holding tanks odoriferous air wet chemical scrubber be replaced with a new wet chemical scrubber system. The new system will be designed to treat 10,150 cfm of flow. The design parameters associated with the new sludge holding tanks odor control system are outlined in Table 12 below:

Table 12 Sludge Holding Tanks Wet Chemical Scrubber Design Criteria

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Required Removal
			Min./Avg./Max. H ₂ S (ppm)	
Digested Sludge Holding Tanks	12	10,150	5/25/50	>99% H ₂ S
Wet Chemical Scrubber Configuration		Dual Stage Scrubber with Caustic and Hypochlorite Stages		
Scrubber Odorous Air Fan Materials of Construction		FRP		

10.5 Biosolids Building

It is proposed that the biosolids building existing wet chemical scrubber system be replaced with a new wet chemical scrubber that can handle the air flow calculated at 20,500 cfm as indicated in Section 9. The design parameters associated with the new biosolids building odor control system are outlined in Table 13 below:

Table 13 Biosolids Building Dry Media Scrubber Design Criteria

Facility	Air Changes Per Hour	Air Flow Required (cfm)	Expected odor compounds concentration	Required Removal
			Min./Avg./Max. H ₂ S (ppm)	
Biosolids Building Equipment Area	12	20,500	1/5/10	>99% H ₂ S
Wet Chemical Scrubber Configuration		Dual Stage Scrubber with Hypochlorite and Acid Stages		
Scrubber Odorous Air Fan Materials of Construction		FRP		

The wet chemical scrubber will employ an acid stage to target ammonia based odors that are expected to be prevalent in the Biosolids Building compared to hydrogen sulfide based odors.

10.6 Sampling

Before opting for any of the recommended odor treatment upgrades it is recommended that odor sampling be conducted to assist in the proper sizing and selection of odor control technology and treatment equipment. Odor sampling (using sulfide monitors and grab bag sampling for organic based odors) will provide information on compounds causing odor and their respective concentrations. Even though hydrogen sulfide is the primary cause of odors at wastewater treatment facilities, speciation of odorous compounds will help in choosing a treatment technology if the odor is caused by something other than hydrogen sulfide. Also, installing an odor data logger (such as those offered by Acrulog or Thermofisher (Odialog)) at the digesters should be considered for the strategic addition of iron salts to control sulfide odor. This will benefit the anaerobic digestion process monitoring as elevated sulfide levels in the digesters inhibit methane gas production.

10.7 Weather Station

The closest weather station for OWRF is station KPVU located at Provo Municipal Airport, Provo, Utah. The station is approximately six miles away from the OWRF. Thus, data from this station may not be a true representation of the weather conditions such as wind direction, wind speed, precipitation, etc. at the OWRF. Additionally, because of the presence of a lake, and buildings between Provo Municipal Airport and OWRF the wind direction and speed may differ at the two sites. Considering the wind rose diagram presented in this report, the wind rose from the weather station at OWRF will be a helpful tool to track site specific odor dispersion. As discussed in Section 4, OWRF staff was not able to determine if the odor at the complainants' location was because of OWRF or Utah lake. Thus, it is recommended to install a weather station at OWRF to log weather conditions and wind direction at the site.

10.8 HVAC evaluation

It is recommended that the HVAC systems be evaluated in buildings where odor control upgrades are to be conducted to ensure proper supply and exhaust air balances and to achieve interior open area desired climate and temperature control. The following building interior areas are discussed with regards to HVAC considerations:

- Headworks Building – heating and cooling considerations of intake air at 12 air exchanges for the building above cover spaces.
- Mixed Flow Pump Station Building– no HVAC or air changes requirements – Wet well areas are not part of the buildings enclosed spaces.
- Biosolids building electrical and office areas are provided with heating and cooling systems separate from those systems used for the equipment area. Currently, the biosolids equipment area is equipped with roof mounted air handling units that provide evaporative cooling and or heating.

NFPA ventilation requirements must be carefully considered for any future odor control upgrades and building modifications to gain the required electrical and building permits. Any upgrades to the OWRF building HVAC systems could require NFPA classification of building areas.

10.9 Proposed Location of Scrubbers

OWRF site was evaluated to locate the recommended scrubbers. Space availability and the distance from the facility were primarily considered for locating the scrubbers. These locations can be reevaluated considering other site constraints. Figure 17 below shows the proposed location of the recommended scrubbers



Figure 17 Proposed New Odor Control Treatment Equipment Locations

APPENDIX G. **Power Distribution Study**



OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
POWER DISTRIBUTION STUDY

OREM WATER RECLAMATION FACILITY
CAPITAL IMPROVEMENT MASTER PLAN
POWER DISTRIBUTION STUDY

Date: December 12, 2022
Prepared By: Brian Young, PE
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Table of Contents

1	Summary	1
2	Recommendations	2
3	Existing Utility Power Services	2
4	Electrical Distribution.....	3
4.1	Service 1	3
4.2	Service 2	6
4.3	Service 3	8
5	Existing Standby Power	10
6	Proposed Electrical Distribution and Standby Power:.....	10
6.1	Distribution System Topology	10
6.2	Separate utility services and distributed generation	11
6.3	One Primary Service with Medium-Voltage Switchgear and Distributed Generators	11
6.4	One Primary Service with Medium-Voltage Switchgear and Central Generator	12
7	Condition Assessment:.....	14
8	Metering Communication:.....	15



List of Figures

Figure 4-1 – Service 1 One-Line Diagram.....	5
Figure 4-2 – Service 2 One-line Diagram	7
Figure 4-3 – Service 3 One-line Diagram	9
Figure 6-1 – Separate Service Distributed Generators One-line Diagram.....	11
Figure 6-2 – One Primary Service Distributed Generators One-line Diagram.....	12
Figure 6-3 – One Primary Service Central Generators Single Feed One-line Diagram	13
Figure 6-4 – One Primary Service Distributed Generators Dual Feed One-line Diagram.....	14
Figure 8-1 – Facility Network Diagram 1.....	16
Figure 8-2 – Facility Network Diagram 2.....	17
Figure 8-3 – Typical RTU.....	18

List of Tables

Table 4-1 – Assets to be Scheduled for Replacement or Upgrade	4
Table 4-2 – Assets to be Scheduled for Replacement or Upgrade	6
Table 4-3 – Assets to be Scheduled for Replacement or Upgrade	8
Table 5-1 – Assets to be Scheduled for Replacement or Upgrade	10

1 Summary

The electrical service to the Orem Water Reclamation Facility (OWRF) is provided by one 12.47 Kilovolt (kV) feeder from Rocky Mountain Power and distributed by the utility company to two existing and one proposed service transformers at 480 volt (V), 3 phase (3Ph), 4 wire (4W). Each service feeds an automatic transfer switch (ATS) which feeds a switchboard or motor control center (MCC). A generator is connected to each ATS to provide standby power.

The existing system does not meet the Environmental Protection Agency (EPA) recommendations for reliability and is not readily expandable. Refer to Section 6.1 Distribution System Topology. The system topology with the highest reliability and flexibility is primary metering with central generators and dual feeder distribution.

Several deficiencies in the existing distribution system are identified that should be addressed as soon as possible.

Possible service and distribution topologies as described in the report include:

- Separate utility services and distributed generation
 - Existing configuration
 - Lowest capital cost
 - Lowest reliability with ATS's
 - Lowest Flexibility (not expandable)
- One Primary Service with Medium-Voltage Switchgear and Distributed Generators
 - Highest capital, operation, and maintenance cost
 - Low reliability with ATS's
 - High reliability with Main-Tie-Main Switchgear
 - Lowest Flexibility (not expandable)
- One Primary Service with Medium-Voltage Switchgear and Central Generator
 - High capital cost
 - Lowest operation and maintenance cost
 - Highest reliability with Main-Tie-Main Switchgear and MCCs
 - Highest Flexibility (expandable)

Existing electrical power distribution system data was obtained from the Power system Study for the City of Orem WRF, Project # 374-19-01, September 21, 2021, produced by Bower Collins & Associates.

2 Recommendations

The following are the recommendations for the distribution system:

- The existing distribution system should be maintained until a facility upgrade or expansion requiring additional power is planned.
- When an upgrade or expansion is planned, we recommend upgrading the electrical utility service to primary metering with new medium-voltage switchgear and feeders.
- We recommend the system design to include portable generator tap boxes or dual feeders to each process area. If a major electrical upgrade is included, we recommend dual feeders with new transformers and double-ended, main-tie-main switchboards and motor control centers (MCCs).
- We recommend that all switchboard and MCCs include metering that is monitored via the facility Supervisory control and data acquisition SCADA system using the existing remote terminal unit (RTU) Ethernet Switches and fiber optic communications infrastructure.
- We recommend that all deficiencies identified in the report be corrected as soon as possible.

3 Existing Utility Power Services

The electrical service to OWRF is provided by one 12.47 Kilovolt (kV) feeder from Rocky Mountain Power. The utility feeder is routed underground to a utility transformer near the RAS-WAS Pump Station, another utility transformer near the blower building, and a proposed third utility transformer will be provided under the future Tertiary Reuse Project. The transformers are owned by Rocky Mountain Power. The secondary of each transformer is connected to a main circuit breaker housed in a Service Entrance Section (SES). The details associated with these services are as follows:

1. Service 1:
 - a. 480/277V, 3Ph, 4W
 - b. Utility fault current contribution 5,193 Amps
 - c. 1,500 kVA Transformer
 - d. 2,000 Amp switchboard
 - e. 608kW, 861A Peak Demand 1/19 to 8/21
2. Service 2:
 - a. 480/277V, 3Ph, 4W
 - b. Utility fault current contribution 5,138 Amps
 - c. 1,500 kVA Transformer
 - d. 2,000 Amp switchboard
 - e. 844kW, 1,195A Peak Demand 1/19 to 8/21
3. Proposed Service 3:
 - a. 480/277V, 3Ph, 4W

- b. Utility fault current contribution Unknown
- c. Utility Transformer to be installed
- d. 3,200 Amp switchboard

The utility peak demand was derived from utility bills from the past two years as shown in summary in Appendix A. The peak demand data from the utility is in the form of peak kW. The kW data was converted to Amperes using a power factor (pf) of 85% using the formula $A = kW \times 480 \times \text{SQRT}(3) / (3 \times \text{pf})$.

4 Electrical Distribution

Power is distributed through the facility from each of the services via 3 phase wires and a neutral wire to Service Entrance Switchgear containing a Main Circuit Breaker (MCB). The neutral wire is bonded to ground and terminates in the SES. The load side of the MCB in each SES is connected to an Automatic Transfer Switch (ATS). A generator is connected to each ATS. The ATS will automatically switch the system to generator power in the event of a utility power interruption. Figure 4-1 through Figure 4-3 illustrates the one-line diagrams for each service.

4.1 Service 1

The distribution from Service 1 (PACIFICORP Meter 77248787) consists of an SES rated at 480/277V, 3Ph, 4W, 2000A, 65kAIC with a 2000A MCB. This feeds a 480/277V, 2000A, 3 Pole (3P) ATS. A 1,500kW, 480/277V, 3Ph, 4W standby generator is connected to the standby terminals in the ATS. The ATS serves switchboard SWBD-RP, rated 480/277V, 3Ph, 3W, 1600A with a 1500A MCB, and distribution panelboard DP-CB, rated 480/277V, 3Ph, 4W, 400A with a 400A CB. Panel DP-CB in the chlorine building feeds panel DP-UV which is located in the UV building. DP-UV will be modified to have a new redundant power source from proposed switchboard SWBD-TR. Refer to Figure 4-1.

SWBD-RP provides power to the following facility locations:

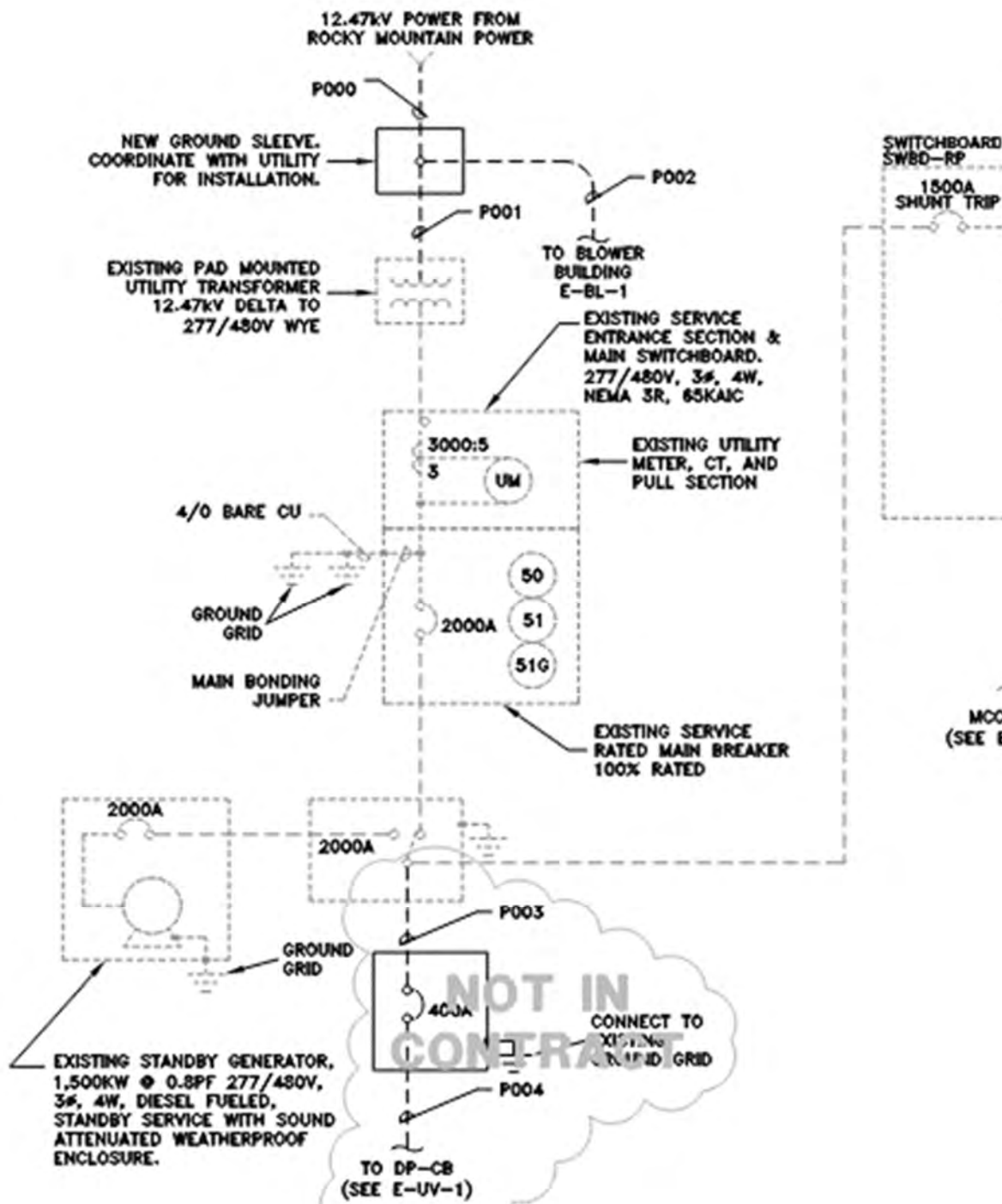
- MCC-RWP
- MCC-DW (Biosolids Dewatering)
- MCC-4 (aerobic Digester)
- Sludge Pump Station
- Clarifier No. 5
- Transformer XMFR-TP
- MCC-3 (RP Building)
- MCC-5 (RP Building)
- DAF Building
- Sump Pumps
- Clarifier No. 6
- Scum Pump Panel
- RAS Actuators
- DAF Building
- MCC-TD (Thermophilic Digester)

Service 1 has the following characteristics:

Table 4-1 – Electrical Service 1 (SES-RP)

Calculated NEC Load	Utility Peak Demand	Current Bus Rating /MCB Trip	Available Fault Current	AIC Rating (Amps)
1,549A	608kW / 861A	2,000A / 2,000A	33.69kA	65kAIC

Figure 4-1 – Service 1 One-Line Diagram



4.2 Service 2

The distribution from Service 2 (PACIFICORP Meter 77248788) consists of an SES rated at 480/277V, 3Ph, 4W, 2000A, 65kAIC with a 2000A MCB. This feeds a 480/277V, 2000A, 3 Pole (3P) ATS. A 625kW, 480/277V, 3Ph, 4W standby generator is connected to the standby terminals in the ATS. The ATS serves switchboard SWBD-BL-2, rated 480/277V, 3Ph, 4W, 2000A, which provides power to all blowers and admin building. Refer to Figure 4-2.

SWBD-BL-2 provides power to the following facility locations:

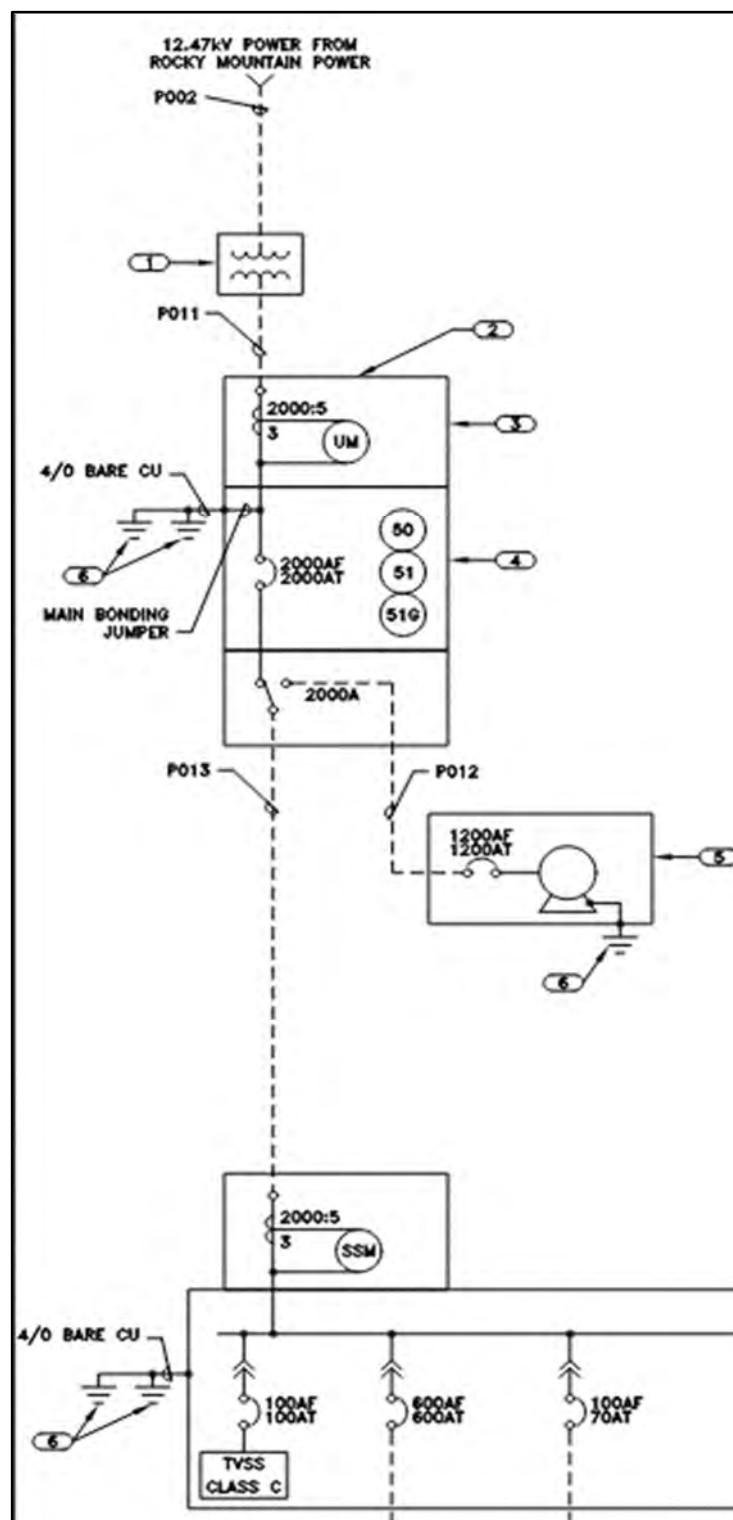
- MCC-BL
- Blowers (BL-M-1/2/3/4/5/6)
- MCC-PS2-1
- MCC-AD
- Admin Building
- Secondary Clarifier No.8 (RAS Gate)

Service 2 has the following characteristics:

Table 4-2 – Electrical Service 2 (SES-BL)

Calculated NEC Load	Utility Peak Demand	Current Bus Rating /MCB Trip	Available Fault Current	AIC Rating (Amps)
1,768A	844kW / 1,195A	2,000A / 2,000A	37.15kA	65kAIC

Figure 4-2 – Service 2 One-line Diagram



4.3 Service 3

Proposed distribution from Service 3 will consist of an SES rated at 480/277V, 3Ph, 4W, 3200A, 65kAIC with a 3200A MCB. This will feed a 480/277V, 3200A, 3 Pole (3P) ATS. An 1850kW, 480/277V, 3Ph, 4W standby generator will be connected to the standby terminals in the ATS. The ATS will serve switchboard SWBD-TR, rated at 480/277V, 3Ph, 4W, 3200A, which provides power to the proposed Tertiary Reuse Water facility. The preliminary available fault current was calculated based on infinite bus primary, which is worst case. This will need to be finalized when utility data is available for the proposed service. Refer to Figure 4-3.

SES-TR provides power to the following facility locations:

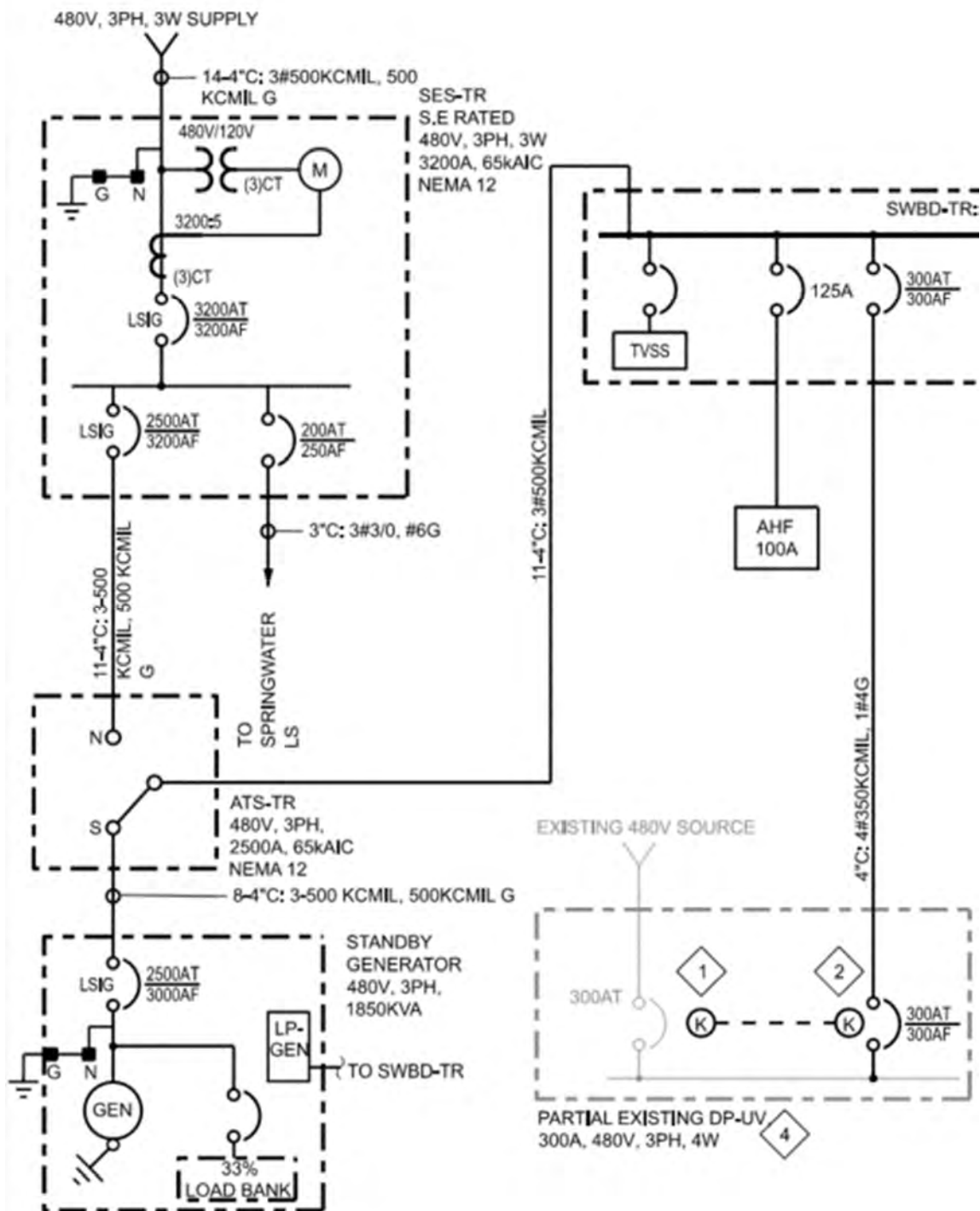
- SWBD-TR
- DP-UV (backup feeder)

Service 3 has the following characteristics:

Table 4-3 – Electrical Service 3 (SES-TR)

Calculated NEC Load	Utility Peak Demand	Current Bus Rating /MCB Trip	Available Fault Current	AIC Rating (Amps)
2442A	NA	3,200A / 3,200A	44kAIC (Prelim)	65kAIC

Figure 4-3 – Service 3 One-line Diagram



5 Existing Standby Power

The facility is presently served by 2 distributed standby power generators that are configured to serve specific systems and selected critical equipment. Service 1 standby power is provided by a 1500kW diesel engine-generator. Service 2 standby power is provided by a 625kW diesel engine-generator. Proposed service 3 standby power will be served by an 1,850kW generator.

The generators ratings, calculated load served, and utility peak demand are shown in Table 5-1.

Table 5-1 – Service Load and Generator Capacity

Generator	Calculated NEC Load	Utility Peak Demand	Generator Rating
Service 1	1549A	608kW / 861A	1500kW (2,255A @ 0.8pf)
Service 2	1768A	844kW / 1,195A	625kW (940A @ 0.8pf)
Service 3 (Proposed)	2442A	NA	1850kW (2,782A @ 0.8pf)

The generators are adequately sized for the historical peak demand load, but not the designed maximum calculated National Electrical Code (NEC) load. Refer to the generator condition assessment in Section 7 Condition Assessment:.

6 Proposed Electrical Distribution and Standby Power:

6.1 Distribution System Topology

Power may be distributed through the facility via multiple 480V utility services or with one primary, medium-voltage (i.e., 12.47kV) service. The calculated demand load on the facility is too large and the distances through the facility are too great to efficiently distribute power at 480V. In the multiple 480V service configuration, power is purchased from the utility at the secondary side of the utility transformer. The utility company owns and maintains all medium-voltage equipment and transformers. The city must pay the utility a secondary service rate for each service.

Power may be purchased from the utility at medium-voltage (primary metering) and distributed through the facility via city-owned equipment. The utility rate is typically lower for primary metering. However, the city would own and maintain the medium-voltage equipment and transformers. New switchgear and transformers would have to be installed to distribute the power.

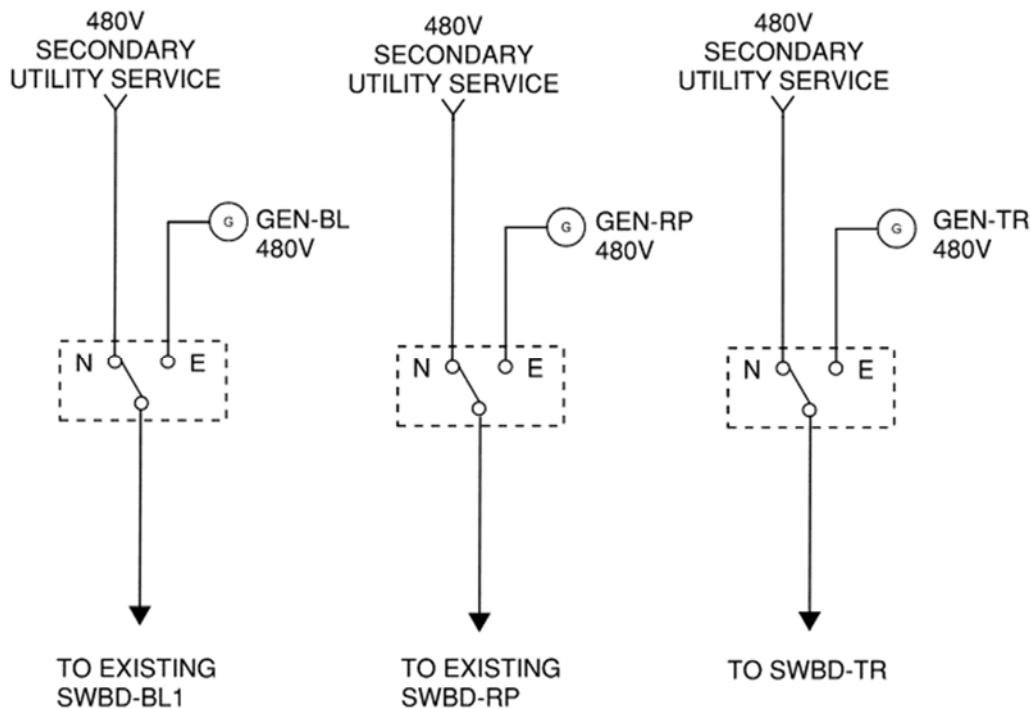
The existing multiple-service configuration has been working satisfactorily and may remain in operation at this time. New or expanded facilities at the facility that increase the load substantially or are not located adjacent to an existing service will require a new or upgraded service. Changing the distribution topology to medium-voltage with a single primary-metered service may be the best option at that time.

According to the Environmental Protection Agency (EPA) document titled “Supplement to Federal Guidelines: Design, operation, and Maintenance of Wastewater Treatment Facilities Design Criteria for mechanical, Electric, and Fluid System and Component Reliability,” (EPA Reliability Document). All critical treatment systems must be provided with standby power in such a manner that no single point of failure may cause an interruption of treatment. Therefore, two power sources are required and the power distribution must include redundancy.

6.2 Separate utility services and distributed generation

This is the existing configuration with 2 existing utility services and a third proposed service and individual generators connected at each service through an ATS. This system does not require the city to maintain the Medium Voltage equipment. This system is the simplest system topology and the least expensive in terms of capital cost and operation and maintenance cost. This system should be adequate until the facility undergoes a significant upgrade or expansion. At least one existing generator may need to be replaced due to age and condition. This system does not meet the intent of the EPA Reliability Document since the ATS is a single point of failure. Refer to Figure 6-1 for a one-line representation of this configuration.

Figure 6-1 – Separate Service Distributed Generators One-line Diagram

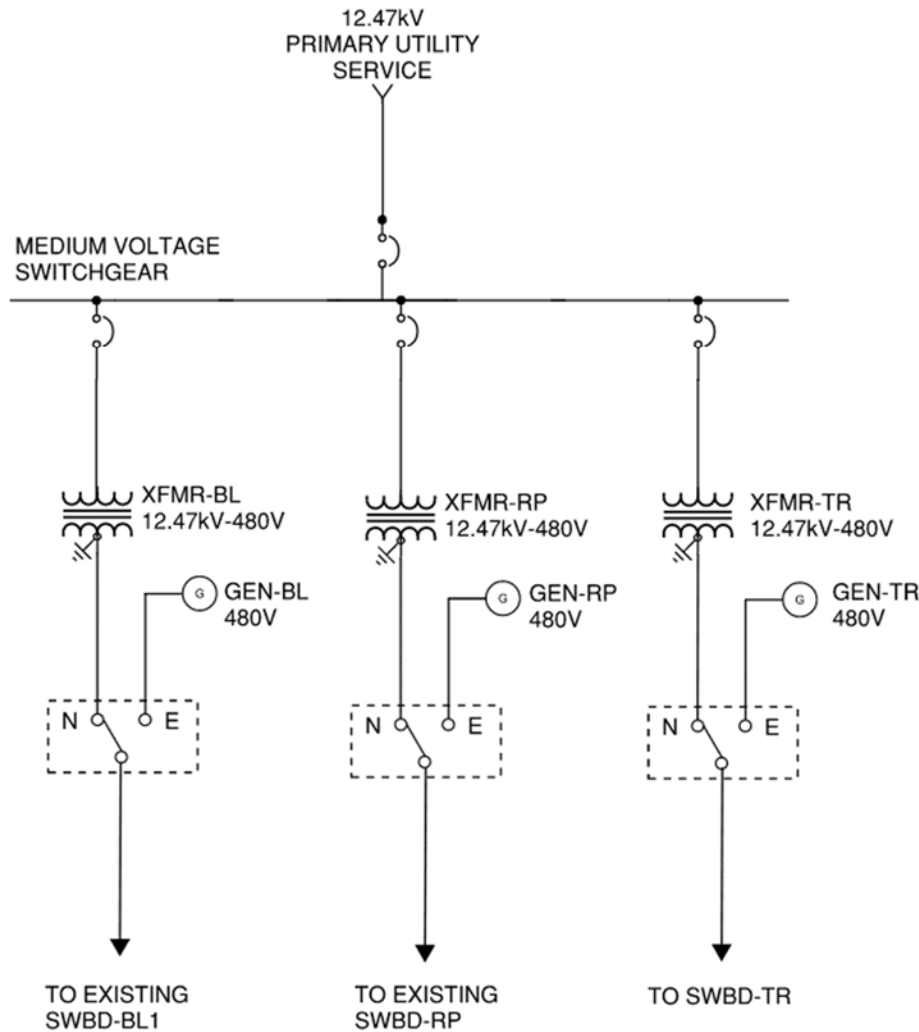


6.3 One Primary Service with Medium-Voltage Switchgear and Distributed Generators

This configuration consists of one primary-metered service with city-owned medium-voltage distribution and transformers. The existing (or new) generators can be connected on the secondary 480V side of the transformers. The city would own and maintain the medium-voltage distribution equipment and transformers in this system. The distributed generators would provide standby power in case of a utility outage and if there is an interruption in the distribution system, such as a transformer or feeder fault. However, there are multiple generators to maintain, and the existing generators would not be configured for facility expansion or new processes. Therefore, additional generators would be required for new facility

upgrades or expansion. This system does not meet the intent of the EPA Reliability Document since the ATS is a single point of failure. Refer to Figure 6-2 for a one-line representation of this configuration.

Figure 6-2 – One Primary Service Distributed Generators One-line Diagram



6.4 One Primary Service with Medium-Voltage Switchgear and Central Generator

This configuration consists of one primary-metered service with city-owned medium-voltage distribution via main switchgear, feeders, and transformers. New generators operating at primary voltage will be connected to the medium-voltage main switchgear with an automatic transfer controller (ATC) and generator paralleling controller. The new medium-voltage Main Switchgear will distribute power to 3 step-down transformers at the 3 process areas previously connected to utility transformers. The existing 480V generators may remain connected to the 480V system but should not be replaced when they are obsolete. The city would own and, therefore, maintain the medium-voltage distribution equipment and transformers in this system.

The generators would provide standby power in case of a utility outage, but not necessarily if there is an interruption in the distribution system, such as a transformer or feeder fault. Internal distribution redundancy may be designed to protect against internal facility outages, such as dual feeders or roll-up generator tap boxes. The roll-up generator tap box option would require the city to purchase an appropriately-sized portable generator. There would be potentially fewer generators to maintain, and the central facility is configured to supply the entire facility and any future facility upgrades or expansions. Refer to Figure 6-3 and Figure 6-4 for one-line representations of this configuration

This system topology has the most flexibility and, with redundant feeders, has the most reliability. It is the most expensive in terms of capital costs and operation and maintenance costs. This system should be considered if the existing generators will be replaced due to their current conditions and if future facility upgrades and expansion is planned.

Figure 6-3 shows the system single feeders from the main switchgear to each process area. It is recommended that portable generator tap boxes be provided with this configuration to provide standby power in case of an internal distribution system fault. The tap boxes would be connected to the 480V bus in each switchgear location. These boxes accommodate quick connection of a portable generator to the switchgear. This system meets the intent of the EPA Reliability Document only if portable generator tap boxes are provided at all critical process locations.

Figure 6-4 shows the utility and generators connected to main-tie-main switchgear with dual feeders to each process area. This is the costliest and most reliable topology. This system meets the intent of the EPA Reliability document.

Figure 6-3 – One Primary Service Central Generators Single Feed One-line Diagram

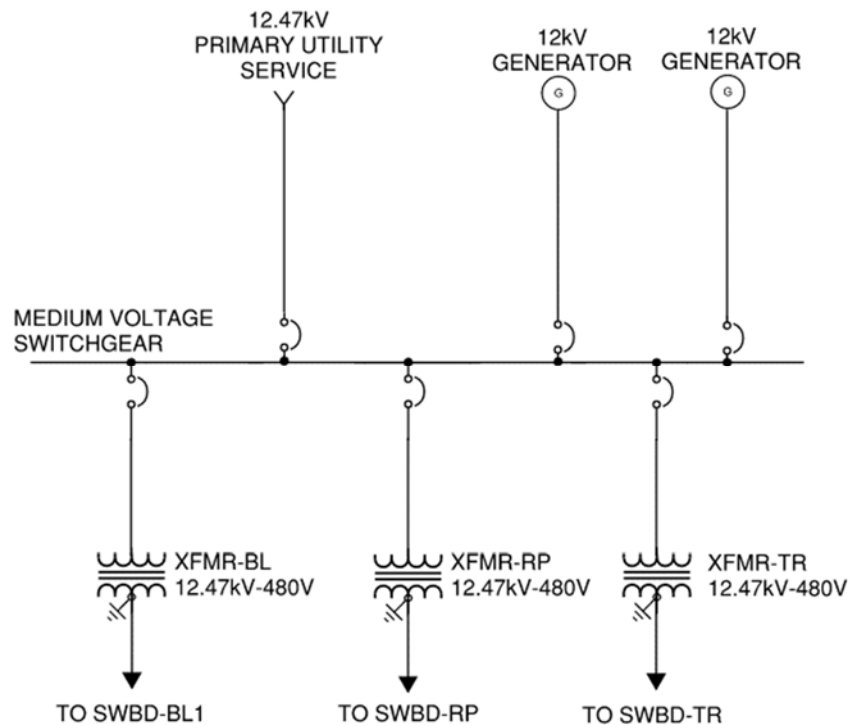
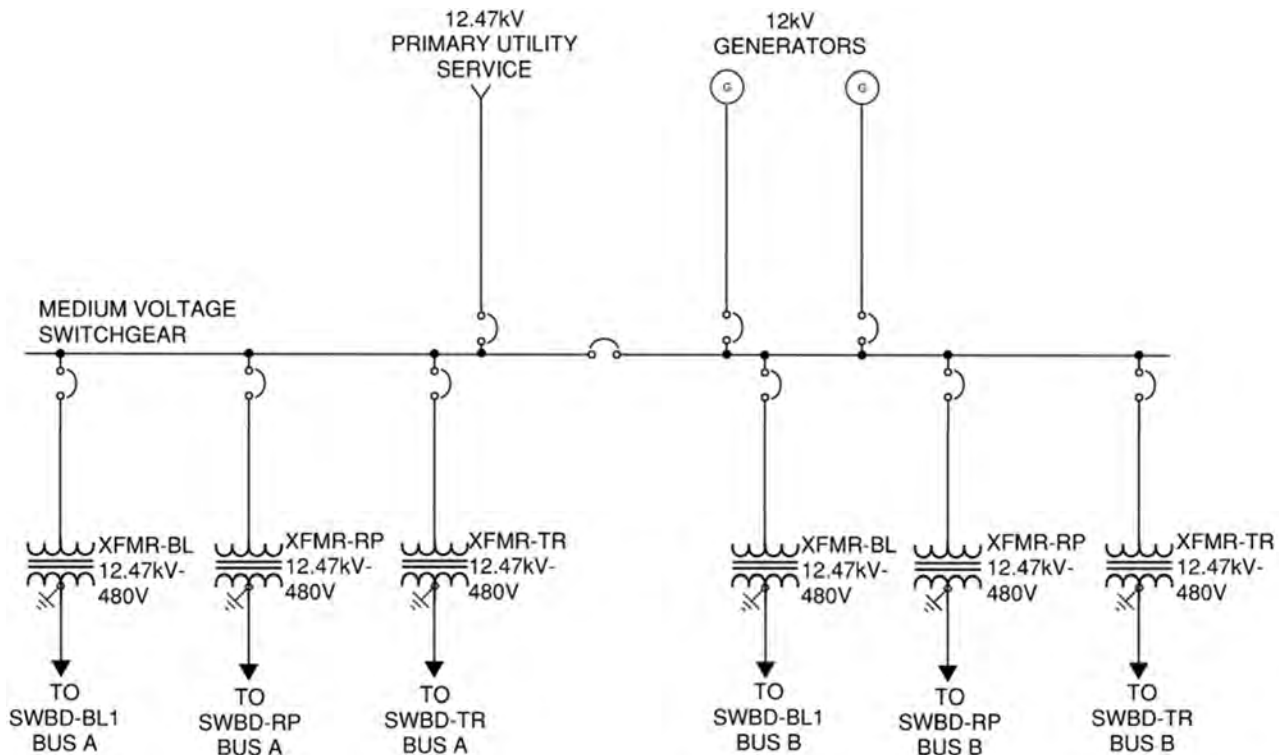


Figure 6-4 – One Primary Service Distributed Generators Dual Feed One-line Diagram

7 Condition Assessment:

Overall, the facility appears to have been maintained properly and is in good working order. However, most of the equipment has exceeded its life expectancy and should be scheduled for replacement.

Water Works Engineers completed a condition assessment for the facility. Refer to the Orem Water Reclamation Facility Capital Improvement Plan Condition Assessment Memorandum dated May 2022. As indicated in the assessment, variable frequency drives (VFDs) installed for the STM Aerators are undersized and are no longer supported. If this equipment fails, replacement may be delayed, resulting in significant process issues.

Equipment identified as in poor condition and at high risk include MCC-4, MCC-AD, Chlorine building electrical panels, DAF Building electrical panels and DAF starter panel, RAS/Was electrical switchgear, MCC3, MCC5, and miscellaneous electrical devices.

An electrical equipment condition assessment was completed for the facility in September 2021 as part of a power system study. Refer to the report titled "Power System Study" prepared for the City of Orem WRF, Project #374-19-01, dated September 21, 2021. That study found some deficiencies, including equipment with ampacity rated lower than required by the NEC, 240V circuit breakers applied in a 480V system, and circuit breakers with insufficient fault current interrupting rating for the available fault current. As of the time of that study, switchboard RP-2 is not sized appropriately and is in poor condition.

Service 1 standby power is served by a 1500kW generator. Per “City of Orem WRF Report 9-21-21”, this generator was installed in 2003 and its condition is rated 3 out of 5.

Service 2 standby power is served by a 625kW generator. Per “City of Orem WRF Report 9-21-21”, this generator was installed in 1986 and its condition is rated 4 out of 5 (on the scale of 1 to 5 with 1 being brand new equipment to 5 being equipment that needs immediate attention).

Figure 7-1 – Service 1 Generator Nameplate



Figure 7-2 – Service 2 Generator Nameplate



8 Metering Communication:

Communications throughout the facility is via fiber optic cables to remote terminal units (RTUs) which contain programmable Logic Controllers (PLCs). The RTUs generally contain Ethernet switches to communicate via Ethernet IP. This Facility is currently using CompactLogix for the PLC control system. The facility is recommending upgrading the PLCs to ControlLogix.

It is recommended that the facility monitor the power usage at each process area switchboard and MCC. Existing metering in the gear may be utilized to send the data to the Ethernet switches in the RTUs. This may require a protocol convertor module to convert from the meter protocol to Ethernet IP. Refer to Figure 8-1 and Figure 8-2 for the existing network configuration and Figure 8-3 for a picture of a typical RTU.

Figure 8-1 – Facility Network Diagram 1

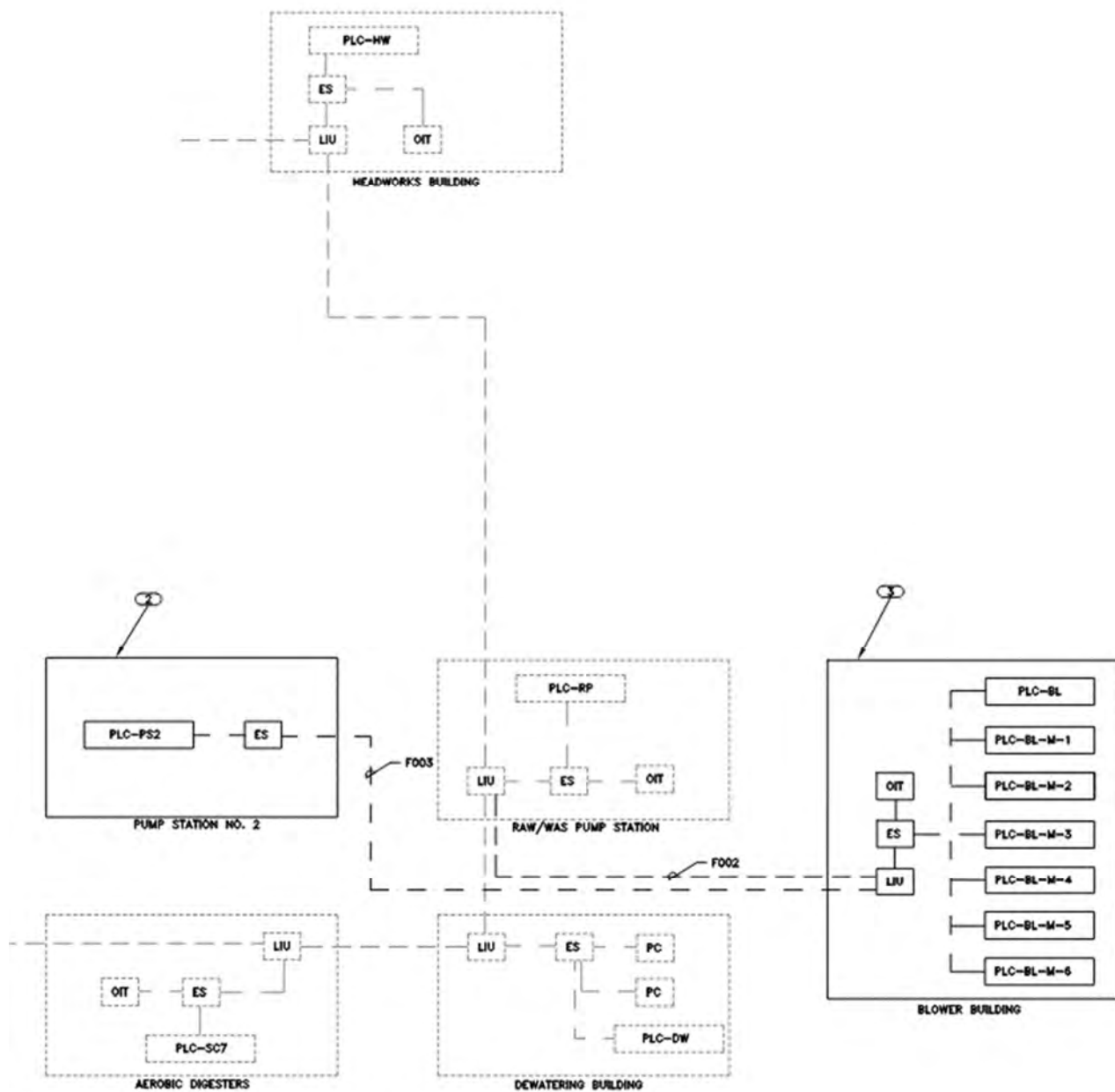


Figure 8-2 – Facility Network Diagram 2

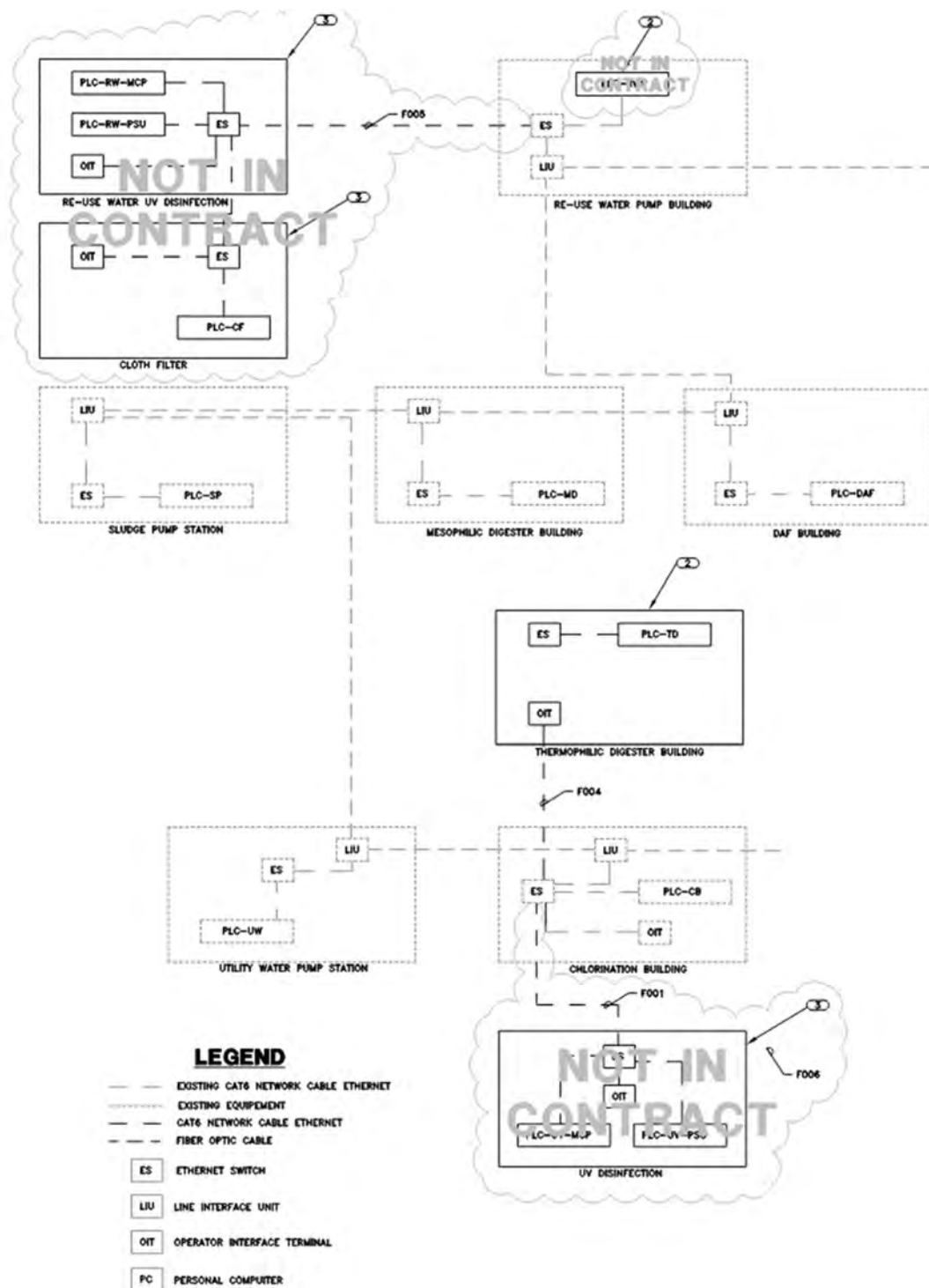
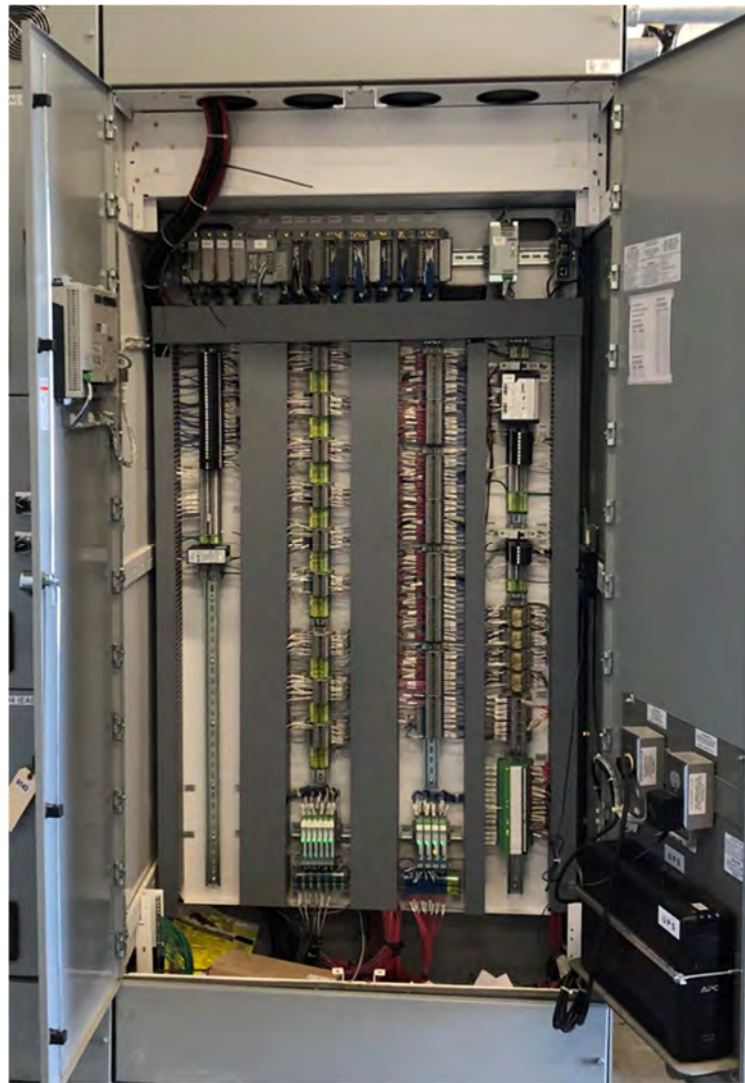


Figure 8-3 – Typical RTU



Appendix A. Utility Peak Demand Data

		Service 77248787	Service 77248788
	Month	Demand (kW)	Demand (kW)
2019	January	510	626
2019	February	526	707
2019	March	547	720
2019	April	471	633
2019	May	474	636
2019	June	461	635
2019	July	517	679
2019	August	498	671
2019	September	567	712
2019	October	608	664
2019	November	571	584
2019	December	588	555
2020	January	585	551
2020	February	592	581
2020	March	593	510
2020	April	545	503
2020	May	497	587
2020	June	518	621
2020	July	512	661
2020	August	512	662
2020	September	533	635
2020	October		
2020	November	578	578
2020	December	438	573

2021	January	466	561
2021	February	446	605
2021	March	444	647
2021	April	432	652
2021	May	408	647
2021	June	530	672
2021	July	518	844
2021	August	484	748
	MAX DEMAND	608	844