GRANTSVILLE
INCORPORATED 1867

WASTEWATER TREATMENT PLANT STUDY

NOVEMBER 2022

FINAL DRAFT

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DEFINITIONS & ABBREVIATIONS

The following is a list of definitions for terms and abbreviations used throughout this plan for reference, presented in alphabetical order.

ADF: Average Daily Flow or the total average flow received by the plant over a typical 24 hour period.

Aerobic: An environment with sufficient dissolved oxygen to allow aerobic microorganisms to thrive.

Anaerobic: An environment with little to no available oxygen. This environment is required by certain microorganism and is used primarily for certain types of digestion and for biological phosphorus removal from wastewater.

Anoxic: An environment with relatively low dissolved oxygen levels in which typical aerobic microorganisms cannot thrive.

BNR: Biological Nutrient Removal – term used to describe biological (i.e. non-chemical) treatment processes to remove nutrients such as phosphorous and nitrogen. BNR traditionally consists of anaerobic and anoxic processes.

BOD: Biological Oxygen Demand, the amount of dissolved oxygen needed by aerobic microorganisms in water to break down and process organic material. This is a typical measure of the loading or "strength" of wastewater entering into a wastewater treatment plant.

Biosolids: Nutrient rich organic material produced from waste sludge at wastewater treatment plants, frequently used as compost.

Denitrification: The anoxic (low oxygen environment) process by which nitrates (e.g. NO_3, NO_2 etc…) are converted to nitrogen gas (N_2) by special denitrifying bacteria that thrive in anoxic environments. Conversion of nitrates to N_2 essentially removes nitrogen from wastewater, reducing the overall total nitrogen content of the water.

GPD: Gallons Per Day.

GPCD: Gallons Per Capita (per) Day.

Effluent: Term used for the treated wastewater from the treatment plant that is being discharged from the plant to its discharge point, typically an adjacent stream, canal, or other surface waterway.

ERC: Equivalent Residential Connection, a standard unit that represents wastewater flow and demand from one typical residential household.

HRT: Hydraulic Retention Time, references the design average storage time a given basin or volume provides for a given flow rate.

Influent: Term used for the raw, untreated wastewater flow from the sewer collection system into the wastewater treatment plant.

MGD: Million Gallons (per) Day.

MLSS: Mixed Liquor Suspended Solids, a measurement of the concentrations of the suspended solids in an aeration or other biological treatment basin at a wastewater treatment plant.

NH_3: Chemical formula for ammonia, a common component of wastewater.

NO_x: Generic chemical formula for the family of nitrate/nitrite type compounds, essentially any dissolved compound in wastewater that consists of a combination of nitrogen and oxygen atoms.

Nitrification: The aerobic (oxygen rich environment) process by which ammonia is converted to nitrates (e.g. NO_3) by nitrifying microorganisms.

O_2: Chemical formula for oxygen gas.

PAO: Phosphorous absorbing organisms

PHF: Peak Hour Flow or the anticipated maximum flow rate occurring during the peak hour over a typical 24 hour period.

Post: Post Consumer Brand (Formally Malt-O-Meal) Foods.

Sludge: Mixture of solids from clarifiers and biological process basins and other solids removal processes consisting of a mixture of organic and inorganic material. Sludge is routinely removed from the main processes basins and sent to digesters for additional treatment.

TN: Total nitrogen, a measurement of the total nitrogen in a given water sample.

TKN: Total Kjeldahl Nitrogen is the total concentration of organic nitrogen and ammonia in a given water sample. This specific parameter is commonly measured for wastewater applications as it gives more accurate nitrogen loading in terms of impact and capacity for wastewater treatment plants.

TSS: Total Suspended Solids, a measurement of all solids, both organic and inorganic, contained in a given water or wastewater sample. This is another standard measure of the loading or "strength" of wastewater entering into a wastewater treatment plant.

UAC: Utah Authority Code.

UPDES Utah Pollution Discharge Elimination System

UV: Ultraviolet light, UV light is a common method used to disinfect wastewater.

WLF: Western Liberty Foods.

WWTP: Wastewater treatment plant, referencing the City of Tremonton's wastewater treatment plant.

EXECUTIVE SUMMARY

This study establishes the design criteria for growth and wastewater treatment needs of the Grantsville City Wastewater Treatment Plant (WWTP). Four alternatives were analyzed to meet the City's projected growth and wastewater treatment demands. A summary of these alternatives, their estimated capital, O&M, and 20-year net present value costs, and recommended course of action for WWTP expansion and improvements are summarized herein.

The current WWTP includes screening, aerated lagoons, and ultraviolet (UV) disinfection to treat wastewater. This facility is designed to treat up to 1.5 MGD but is unable to remove phosphorus (P) to meet permit nutrient limits. Plant improvements and expansion will be required to meet current nutrient limits and to accommodate increased flow and loading as the population increases. Chemical addition and mixing could be added to the existing lagoon system to treat up to ~1 MGD to meet all permit requirements (including effluent P). Chemical P removal above 1 MGD becomes impractical due to the amount of chemical required. Even so, growth is anticipated to exceed 1 MGD soon, and expansion beyond 1 MGD (and 1.5 MGD) is recommended.

The current daily average flow (ADF) to the plant is 0.86 MGD with an estimated 2022 population of 13,547, yielding a calculated average influent of 65 gallons per person per day (gppd). Growth estimates for the service area range from as low as 2.43% to 9-10% in the short-term. Growth based on actual measured influent to the plant has averaged 5.1% since 2019. A 3 MGD facility serving a population of 45,500 by the year 2042 is assumed in this study, which equates to an average growth rate of 6.25% over the next 20 years (through 2042). At an assumed rate of 3 people per Equivalent Resident Connection (ERC), this corresponds to 15,167 ERCs by 2042.

Assuming 65 gppd and this growth rate, the WWTP should be expanded to treat 3 MGD ADF and a peak hour flow of 7 MGD. Based on available WWTP data and design guidelines, the recommended design concentrations for BOD and TSS are a 250 mg/L each. This corresponds to a design loading of 6,255 lbs./day (0.137 lbs. per person per day) for both BOD and TSS. Design influent TKN and total P are 55 mg/L and 6.0 mg/L respectively. At 3 MGD, this yields 1,376 lbs. TKN and 150 lbs. of P per day. Finally, this study investigated alternatives to produce Type I reuse water, based on preferences and input staff. Type I reuse water is high quality effluent that can be used in many irrigation applications including public open spaces, residential, commercial, and agricultural. The existing WWTP site could accommodate some winter storage (~100-150 million gallons\) if storage is desired for reuse purposes. Additional storage is required if all winter effluent (~180 days' worth) is intended for reuse applications. There are a variety of treatment options that would meet these demand and design criteria. After discussion with the operators and the City staff, four options were selected for detailed analysis and comparison in this study. The options and their estimated capital, O&M, and 20-year NPV costs are summarized in the following table:

Total 20-Year NPV Comparison				
Process	**Cap Ex**	**2022 Op Ex**	**20-Year NPV Op Ex**	**Total 20-Year NPV**
Fine Bubble Diffusers (3 MGD)	$ 25,727,917	$ 417,392	$ 6,442,544	**$ 32,170,461**
Oxidation Ditches (3 MGD)	$ 27,716,332	$ 468,670	$ 7,234,032	**$ 34,950,364**
MBR (3 MGD)	$ 29,547,590	$ 600,134	$ 9,196,338	**$ 38,743,928**
Lagoons (1 MGD)* & Fine Bubble Diffusers(2 MGD)	$ 26,238,355	$ 913,062	$ 14,093,314	**$ 40,331,669**

All four options would handle the design loading and meet permit effluent limits. The parallel system is the most expensive to operate (due to chemical demand and energy inefficiency) and is overall the least favored. MBR offers consistently high quality effluent, but its primary advantage, namely compact footprint, is of lesser concern here and likely does not merit the higher capital and O&M costs. Both the oxidation ditch and fine bubble diffuser options appear to be the most practical and cost effective alternatives, with diffusers appearing slightly more favorable. Overall, the fine bubble diffuser alternative is recommended based on our cost analysis, the needs of the City, and input from City and WWTP operating staff. This alternative offers good energy efficiency, relatively easy maintenance, easy expansion and scaling to meet growth beyond 3 MGD, and can produce Type I reuse water if tertiary filtration is added. Funding and design efforts should commence as soon as possible in order to allow for design, construction, and startup of new facilities in time to avoid violating permit conditions and to accommodate growth.

CHAPTER 1 - INTRODUCTION

1.1 Introduction and Purpose

This document is a study for the Grantsville City Wastewater Treatment Plant (WWTP), located in Tooele County, Utah. The purpose of this study is to establish design criteria for current and future wastewater treatment needs of the WWTP service area and provide recommendations for expansions and improvements of the plant to handle projected loading. The study reviewed growth projections from multiple sources including the 2022 *Capital Facilities Plan and Impact Fee Analysis* prepared by Ensign Engineering (Ensign, 2022), municipal population projections from the *Utah Governor's Office of Management and Budget*, and the *Utah Long-Term Planning Projections* as prepared by the University of Utah's Kem C. Gardner Policy Institute in 2022 (K.C. Gardner, 2022). Data from 2019 thru June 2022 from the WWTP was analyzed to determine specific concentrations of key wastewater constituents and refine design criteria to better represent actual conditions in the service area.

This plan summarizes available data and projections to:

- Establish the design criteria for short-term and long-term expansion of the WWTP including projected influent flows, organic loading, nutrient loading, and solids handling based on projected population growth.
- Review the condition and capacities for all major processes and equipment at the WWTP.
- Explain and justify the recommended equipment, processes, and upgrades at the WWTP to accommodate projected growth.
- Present preliminary design and site plans for the recommended expansion alternatives, as well as establish a preliminary budget for these improvements.
- Present 20-year NPV including installation/capital costs for selected alternatives as well as estimated operation and maintenance expenses.
- Summarize remaining capacities at the WWTP, projected 20-year growth, and required expansion/improvements at the WWTP to accommodate 20-year growth.

1.2 Wastewater Treatment Plant Overview

The Grantsville City WWTP is located at 900 North Race Street. The current facility consists of a pump station, headworks building (screening and grit removal), aerated lagoons, additional storage lagoons, and disinfection. The site includes one lagoon equipped with submerged diffusers, two additional lagoons equipped with surface aerators, a fourth lagoon used for effluent storage, and five additional lagoons that are occasionally used for temporary overflow/storage and flow balancing. Treated effluent from the WWTP discharges into a drainage ditch that flows into the Blue Lakes area northeast of the lagoons. Blower equipment, controls, and electrical gear for diffusers and aeration equipment are housed in a building adjacent to the headworks at the southwest corner of the site.

The treatment plant removes solids, organic material, nutrients, and other constituents from wastewater as required by the WWTP's operating permit, issued to Grantsville by the State of Utah Department of Water Quality (Permit UT0021130). The WWTP is rated to treat up to 1.5 MGD (average daily flow by month), though its true capacity is limited by its ability to meet effluent nutrient requirements (specifically phosphorous). The WWTP uses a series of mechanical and biological processes to treat wastewater to meet permit requirements. After mechanical removal of larger debris and heavier solids with screens and grit chambers, wastewater enters the aerated lagoons that rely on microorganisms to break down and remove organic materials and nutrients from the wastewater. This biological activity produces secondary solids known as sludge that settles and collects in the bottom of the lagoons. These solids undergo additional anaerobic breakdown over time, but inert solids and material do gradually accumulate in the lagoons. Flow eventually passes through ultraviolet (UV) disinfection units to inactivate bacteria and viruses prior to discharging into the drainage ditch.

The lagoons were updated in early 2000s to improve reliability for removal of wastewater constituents including biological oxygen demand (BOD), and ammonia. As stated, the existing plant can theoretically treat up to 1.5 MGD, but more stringent effluent phosphorous requirements implemented in the 2019 permit reduce their practical capacity. This is discussed in more detail in Chapter 3, but in summary the plant has difficulty reliably meeting effluent phosphorus (P) limits for flows above ~0.5 MGD. At current flows (~0.85 MGD), additional chemical addition is needed to meet the permit; operation beyond 1 MGD, even with chemical addition, becomes impractical and problematic due to the amount of required chemical.

Operators have noted significant sludge accumulation in the first 2 lagoons. In some locations, sludge has accumulated to the water surface; this reduces the capacity and overall efficiency of the system and indicates that the ponds need to be dredged. Note that with chemical addition for P removal, sludge will accumulate considerably faster, meaning dredging would be required much more frequently with their continued use at current or higher flow rates. Other improvements and rehabilitations are also required to extend the service life of the lagoons, as detailed in Section 3.2.

In review, while the lagoons can theoretically treat 1.5 MGD, their practical capacity is limited to 1 MGD due to effluent P requirements. To even achieve 1 MGD capacity, installation of chemical addition would be required to enhance P removal efficiency. Based on growth projections and anticipated loading from the service area, the WWTP will need to be upgraded and expanded well beyond 1 MGD. The following chapters summarize our recommended design criteria for the plant, upgrade alternatives that were explored and discussed with operating staff, and our recommended action plan to ensure the facility is suited to treat current and future loads to meet permit requirements.

CHAPTER 2 - DESIGN CRITERIA SUMMARY

2.1 Population and Loading Estimates

The WWTP receives municipal wastewater from the City's collection system. Wastewater is a mix of residential, commercial, and light industrial waste streams; laboratory data show that its content is typical for municipal service areas. Influent flow data including flow rates, biological oxygen demand (BOD), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), ammonia, phosphorous, and effluent water quality measurements from 2019 thru June of 2022 are available and were used to determine per capita loading and flow rates. These per capita loading rates are combined with population growth estimates to establish design criteria for the WWTP. The primary design criteria reviewed and established in this study are:

- Population and Growth (including ERCs)
- Flow (average daily and peak hour flows)
- BOD
- TSS
- Ammonia and Nitrogen
- Phosphorus

2.1.1 Existing Population, Projected Growth & ERU's

Growth projections for the next 10-20 years have been analyzed and discussed by multiple parties, and range from 9-10% (Ensign, 2022), to 2.9% by the Governor's Office, to less than 2.4% (K.C. Gardner, 2022). Actual growth based on measured wastewater influent flow for the past 3 years has averaged 5.1%. The 2020 census established Grantsville's population at 12,617, and the current (2022) population estimate based on US Census data is 13,400, representing a growth rate of ~3.4%. While it is difficult to predict actual growth, a reasonable estimate must be established to ensure that the WWTP is expanded to meet future demands without placing undue cost burden on existing users. Aside from high costs per connection, oversized facilities are difficult to operate and maintain, and will pass their expected service life before their full capacity is ever needed. The WWTP should be designed to both facilitate future expansion in the case that growth exceeds expectations and to minimize cost and interruptions to treatment. Typically, wastewater treatment design considers a 20-year growth window, basing design criteria and expansion recommendations on this time frame.

The slower-growth rate models are already underestimating current population by ~1,000 which justifies a higher rate. The Ensign report focuses on the next 10 years of growth; sustained growth of 9%+ beyond this time frame is questionable and would likely result in an oversized (and unduly expensive) WWTP expansion. Upon reviewing the cited growth models and scenarios with City staff, a target 3 MGD average daily flow facility was established, equating to a 20-year service population of 45,500. This target design flow and population is equivalent to an overall average growth rate of 6.25%. This is a reasonable, moderate growth rate that can account for rapid growth in the short-term followed by slowing growth later on. If growth does occur faster, the City will have more capital from collected impact fees available to fund additional expansion. If growth is slower, the plant will not be so over built that existing users and the City fail to receive reasonable value from the expanded plant. Table 2-1 provides a summary of the population growth estimates through 2042.

Costs to construct, operate, and maintain sewer collection systems and wastewater treatment plants are typically divided among existing and future users connected to the system. A common unit used to equate population to sewage flow rates and loading is an Equivalent Residential Connection or (ERC). One ERC represents the contribution of a typical detached, single-family dwelling to the sewer collection system and WWTP. Since population is closely related to ERC count, population growth is used to estimate future ERC's and their impact on flow and loading on the WWTP. For the purposes of this study and to stay consistent with other reports adapted by the City, 1 ERC is considered equivalent to 3 people. This assumption is within normal ranges; many cities in Utah use values ranging from 2.7 to 3.5 people per ERC. As presented in Section 2.1.2 , this equates to 195 gallons per day (gpd) per ERC. Table 2-2 summarizes growth projections and equivalent ERCs through 2042.

Table 2-1: Summary of projected population growth estimates.

Grantsville Population Estimates				
Year	K.C. Gardner Institute	Governor's Office	Aqua (6.25%)	Ensign
2022	12,592	11,789	13,547	14,070
2023	12,898	12,131	14,394	15,477
2024	13,212	12,483	15,293	17,025
2025	13,534	12,845	16,249	18,642
2026	13,864	13,217	17,265	20,413
2027	14,202	13,600	18,344	22,352
2028	14,548	13,995	19,490	24,364
2029	14,902	14,401	20,708	26,557
2030	15,265	14,818	22,002	28,947
2031	15,637	15,248	23,378	31,552
2032	16,017	15,690	24,839	34,392
2033	16,408	16,145	26,391	37,487
2034	16,807	16,614	28,041	40,861
2035	17,217	17,095	29,793	44,539
2036	17,636	17,591	31,655	-
2037	18,065	18,101	33,634	-
2038	18,505	18,626	35,736	-
2039	18,956	19,166	37,969	-
2040	19,418	19,722	40,342	-
2041	19,891	20,294	42,864	-
2042	20,375	20,883	45,543	-

Table 2-2: Summary of recommended population and ERCs estimates.

Grantsville Growth Summary		
Year	Population	ERCs
2022	13,547	4,516
2025	16,249	5,416
2030	**22,002**	**7,334**
2035	29,793	9,931
2040	40,342	13,447
2042	**45,543**	**15,181**

Changes in loading to the WWTP are evaluated in terms of additional flow, which is estimated from new ERC's and population growth. These values are used to project when sewage flow rates and loading will reach critical values that trigger additional expansion or upgrades to the WWTP. This study focuses on growth and recommended improvements to the WWTP for the next 20-years while providing some guidance for expansion and growth beyond this timeframe.

2.1.2 Influent Flow

The current design and permitted hydraulic capacity of the WWTP is 1.5 MGD average daily flow (ADF). Monthly average influent flow data collected from January 2019 through June 2022 are shown in Figure 2-1. The overall median daily influent flow has increased from 0.73 MGD in 2019 to 0.86 MGD in 2022. Peak day flow currently averages 0.95 MGD but has been as high as 1.39 MGD, associated with extended storm events. Peak hourly flow (PHF) has increased proportionately as well, averaging 2.15 MGD in 2022. This represents a peak factor, or ratio of peak hour to average daily flow, of 2.5. This peak factor is on the high end of typical but not unreasonable, especially considering that the WWTP is fed from multiple pumpstations where instantaneous flows can be higher than true peak influent into the collection system. However, as collection systems and service areas grow, peaking factors tend to decrease. Future collection system expansion and coordinated automation of collection system pump stations would also help reduce this peak factor. Thus, a recommended design peak factor of 2.33 is assumed for this study.

Otherwise, a few data points are well above the values cited above. These are attributed to issues with influent flow measurement instrumentation that has since been corrected. Finally, it is noted that flow rates do not vary seasonally. This indicates that inflow and infiltration (I&I) from leaky pipes, groundwater, etc. has minimal impact on the system, which simplifies planning and hydraulic design of the plant.

Both ADF and PHF flow rates are important design factors. Average daily flow controls the sizing of biological processes such as aeration basins, recycle rates, and overall water budgets for disposal, storage, and potential reuse. Peak flow is needed to ensure pump stations, pipelines, and other critical equipment such as screens, clarifiers, and disinfection, are sized to handle high flow events.

Combined with population values, ADF is used to estimate daily flow per person. With current flow averaging 860,000 gallons per day and the present population estimated at 13,651, the daily flow per person is calculated to be 63 gallons per person per day (gppd). Values from 2019 through 2022 range from 60 to 66 gppd. Thus, a value of 65 gppd is recommended and utilized in this study. This is a reasonable value compared with similar calculations we have done for other Utah cities that range from 50 to 80 gppd. This yields a daily flow rate of 195 gpd per ERC based on 3 people per ERC established in Section 2.1.1 .

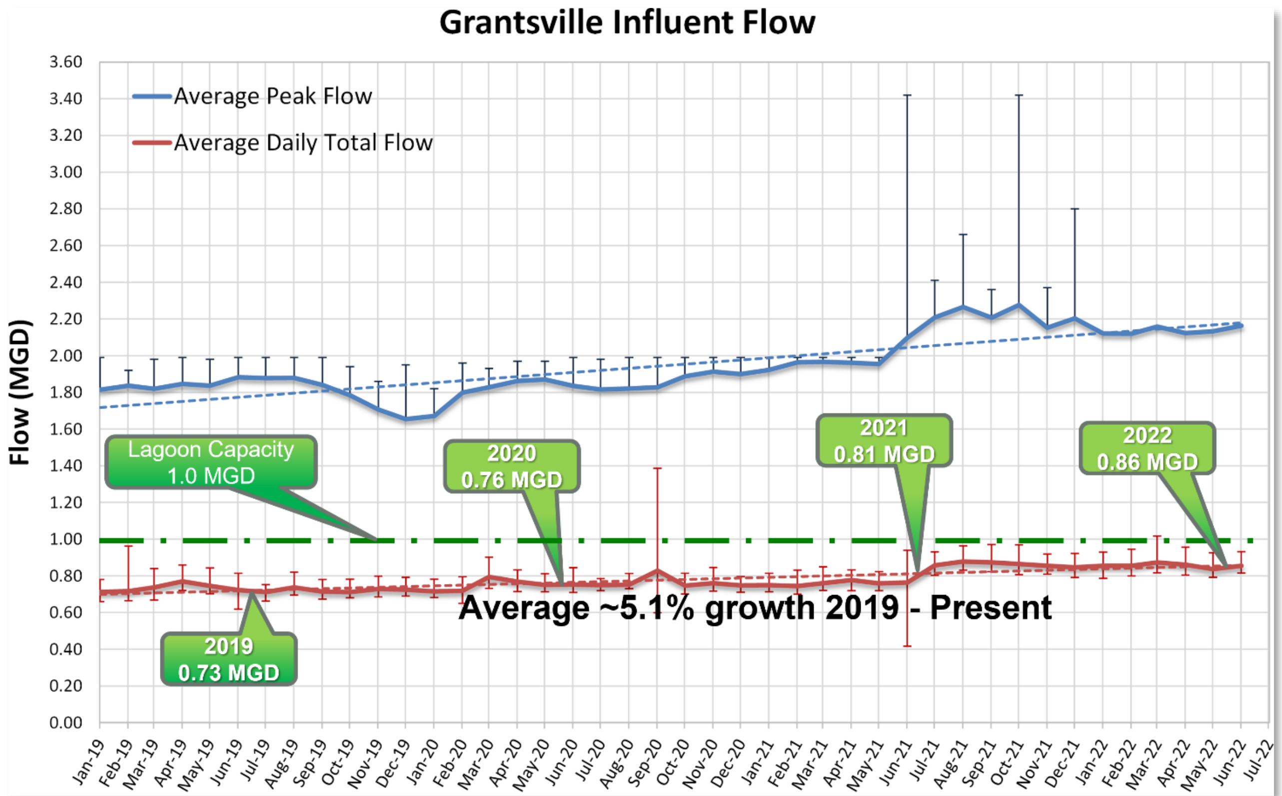


Figure 2-1: Average monthly influent flow of Grantsville.

Using population growth projections from section 2.1.1 and a per capita flow rate of 65 gppd, future flow rates are estimated. The assumed 2042 population is 45,543, yielding an ADF capacity just under 3 MGD. Using a peak factor of 2.33, the design peak hour flow is 7.0 MGD. As noted above, the practical capacity of the existing lagoon system is 1 MGD, meaning any recommended expansion would require increasing capacity by 2 MGD, or installing a completely new 3 MGD facility. The new plant should be designed to facilitate future expansion beyond 3 MGD as well. Figure 2-2 summarizes projected population and flows; Figure 2-3 shows the comparison using ERCs for reference.

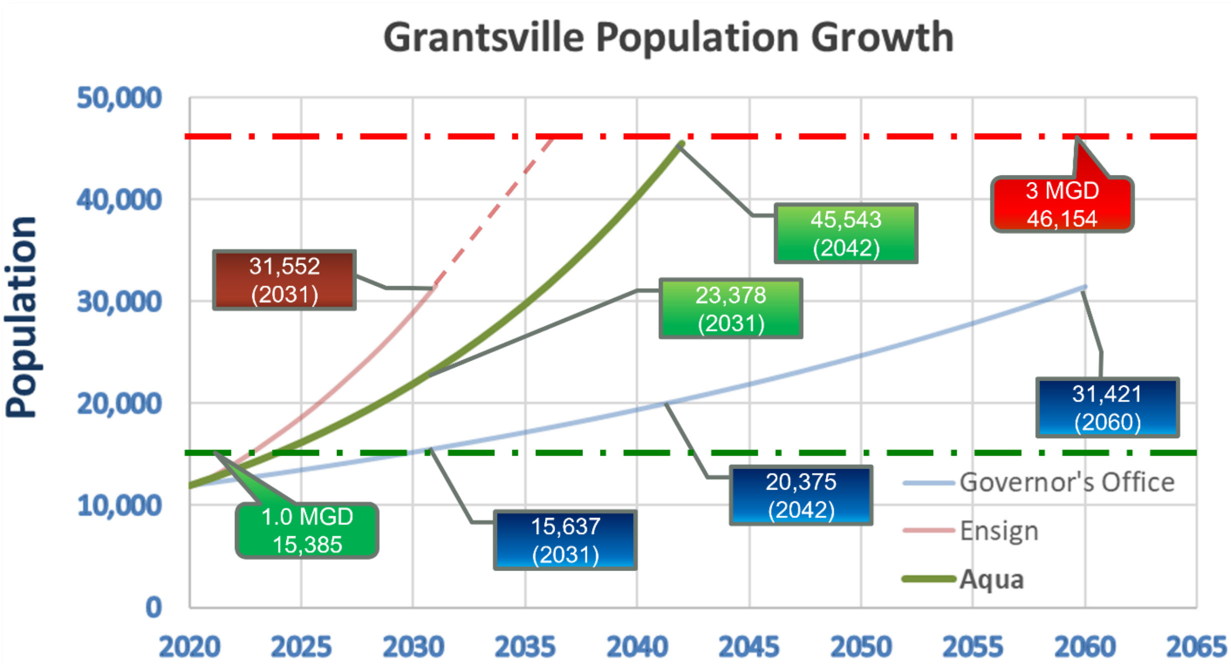


Figure 2-2: Summary of three population growth projections compared to existing and proposed WWTP capacity.

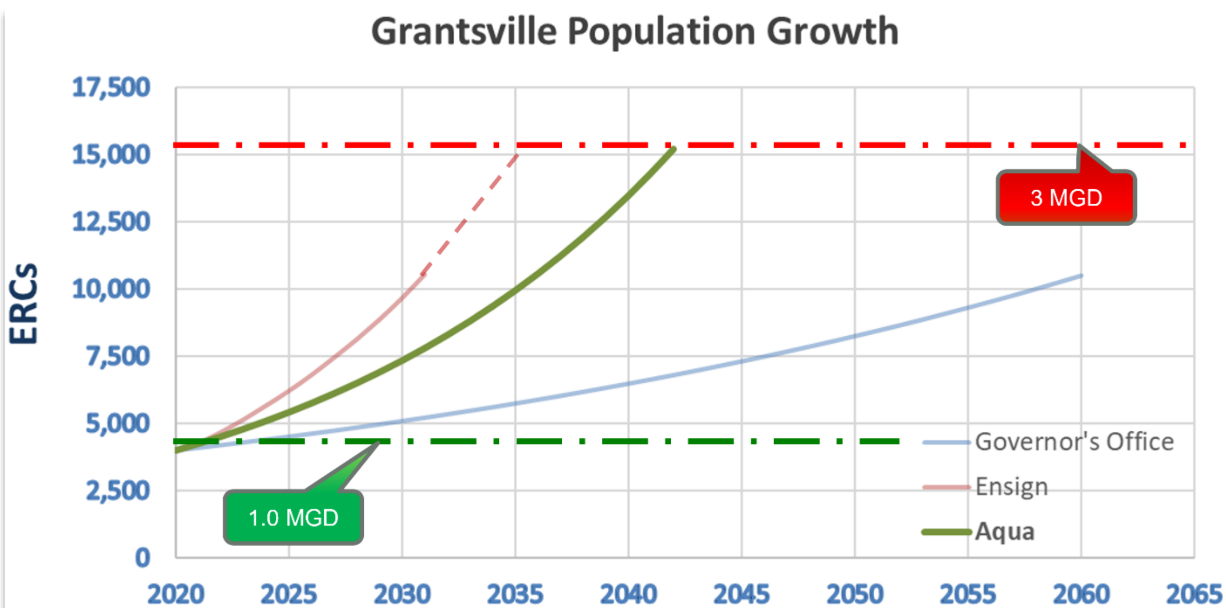


Figure 2-3: Population growth projections shown as ERCs.

2.1.3 Influent BOD and TSS

Influent flow is only one factor when considering the WWTP's loading and capacity. The concentration of constituents or strength of the influent must be considered. A plant may be within its hydraulic capacity but exceeding the design biological and/or solids loading. Specific components of interest for wastewater include biological oxygen demand (BOD), total suspended solids (TSS), and nutrient loading such as ammonia, nitrogen, and phosphorous. The total daily load, determined in pounds per day, is a function of each component's concentration (measured in milligrams per liter) and the influent flow rate. Figure 2-4 and Figure 2-5 summarize influent BOD and TSS data from January 2019 through June 2022.

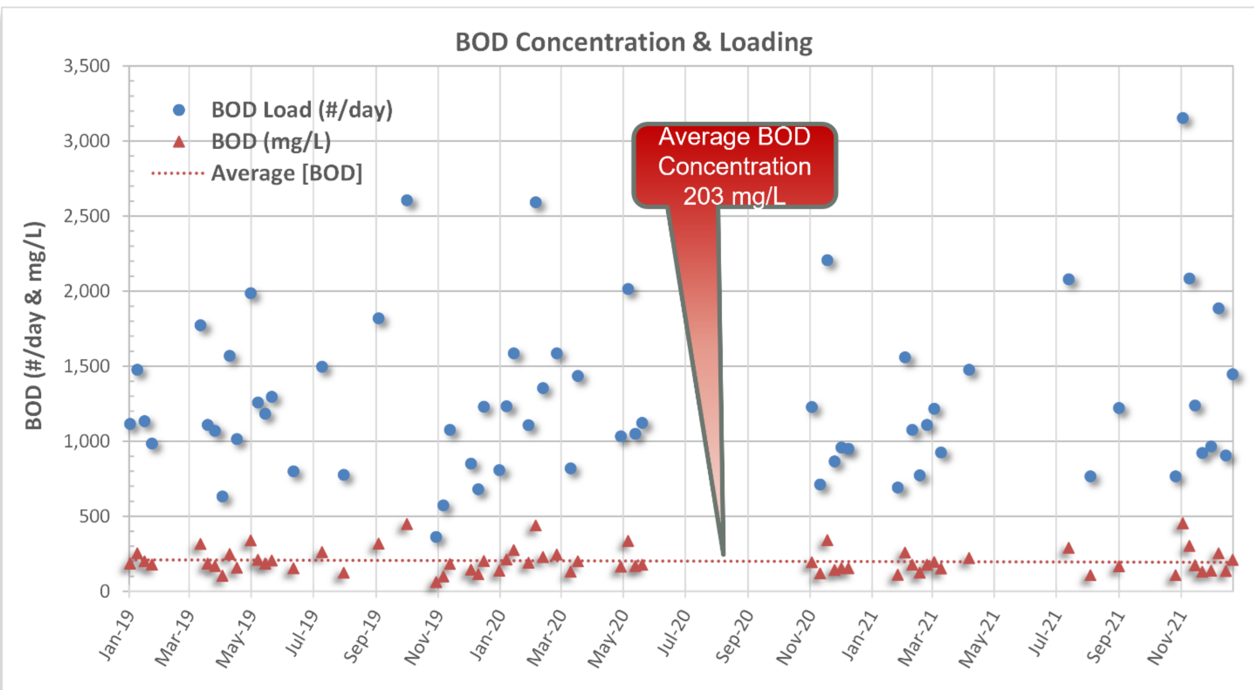


Figure 2-4: Average BOD concentration and loading.

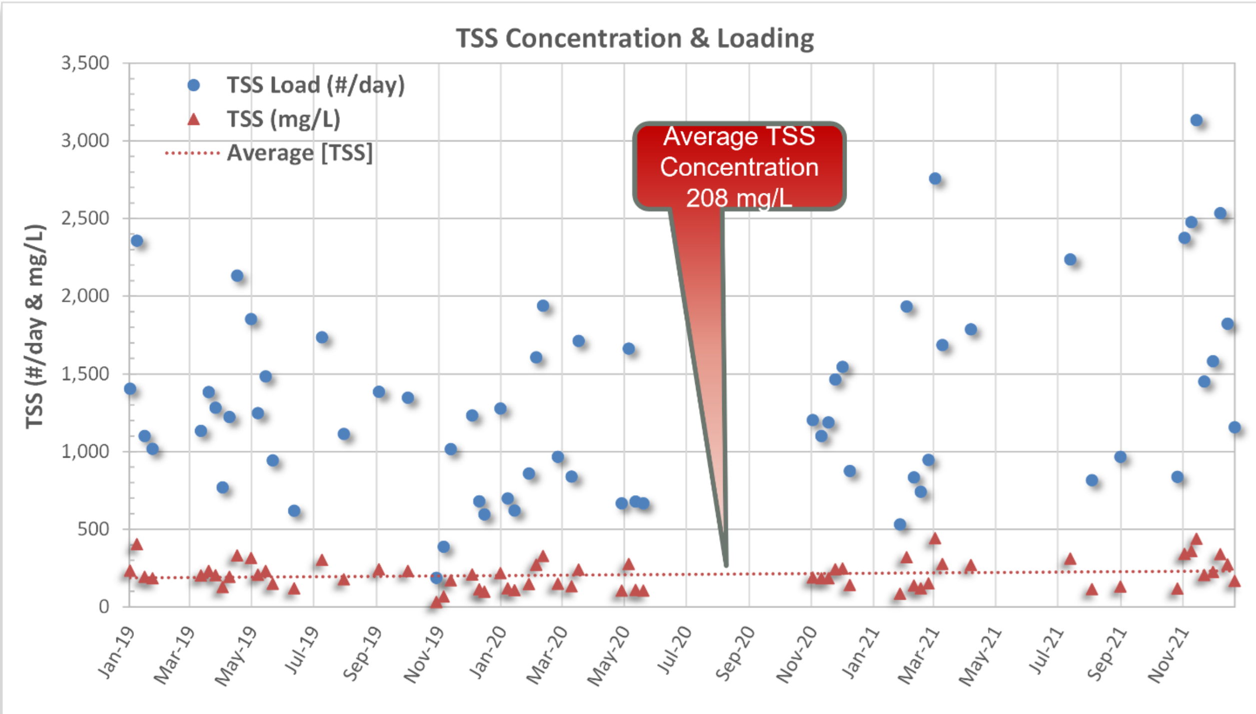


Figure 2-5: Average TSS concentration and loading.

BOD and TSS concentrations have mostly been consistent, with average values of 209 and 208 mg/L respectively. Maximum BOD concentrations up to 454 mg/L have been noted; likewise, TSS as high as 442 mg/L is reported. The average values yield average loading of 1,260 lbs. BOD and 1,310 lbs. TSS per day. This equates to a per capita loading of 0.11 # BOD and 0.12 # TSS per day. Some days report respective BOD and TSS loading as high as 3,154 and 3,134 pounds. High values can result when BOD/TSS concentrations are measured during normal or lower flows (when concentrations may be more typical) but are then followed by high flow events (e.g. from a storm), resulting in higher calculated load than actually occurred. Likewise, temporary spikes in BOD or TSS loading can occur, skewing measured concentrations (and therefore calculated loading) higher than is taking place. In other words, the calculated total loading in pounds is likely higher than reality on days where loading is 2.5 to 3 times average, especially since there are no known point sources that could significantly increase BOD loading.

Recommended daily per capita BOD and TSS design values range from 0.11 to as 0.26 lbs./day (MetCalf, 2003). The State of Utah recommends 0.22 lbs. BOD and 0.20 lbs. TSS per day unless data is available to support otherwise. While some consideration should be given for high loading events, wastewater treatment plants can handle temporary spikes in loading as biological treatment systems are more sensitive to 24–48-hour averages. The data could justify a BOD loading as low as 0.11 # per person per day, or ~5,000 #/day for a 3 MGD plant. This would equate to an influent BOD concentration of 200 mg/L; this is on the low-end of typical, but reasonable. Similarly, a design TSS of 0.12 # per person per day (5,465 #/day at 3 MGD) is justifiable and on the lower end of reasonable. However, with the desire to ensure some buffer capacity in the expanded process, we recommend a design concentration of 250 mg/L for both BOD and TSS. This establishes design loading of 6,255 #/day, or 0.137 # per person per day for BOD and TSS. This is conservative based on available data and captures the 80th percentile of calculated loading.

For reference, reported effluent concentrations of BOD and TSS are both typically well below 5 mg/L, and even maximum reported values are substantially beneath permitted maximum weekly concentrations of 35 mg/L. This indicates that the existing lagoon system is operating well and has sufficient biological capacity for current BOD and TSS loading. The theoretical 1.5 MGD capacity is likely obtainable for BOD and TSS treatment. However, given its limitations for phosphorus removal (discussed in the next section), the practical lagoon capacity is still considered to be 1 MGD.

2.1.4 Influent Nutrient Loading & Removal

Nutrient loading for the purposes of this study includes total nitrogen, ammonia, and phosphorous. Influent TKN averages 55 mg/L, typical for municipal wastewater. Influent total phosphorous ranges from 3.3 to 9.8 mg/L, averaging 5.9 which is also within normal values of 4-6 mg/L (Figure 2-6). It is anticipated that these concentrations will continue with growth, and future loading is estimated accordingly.

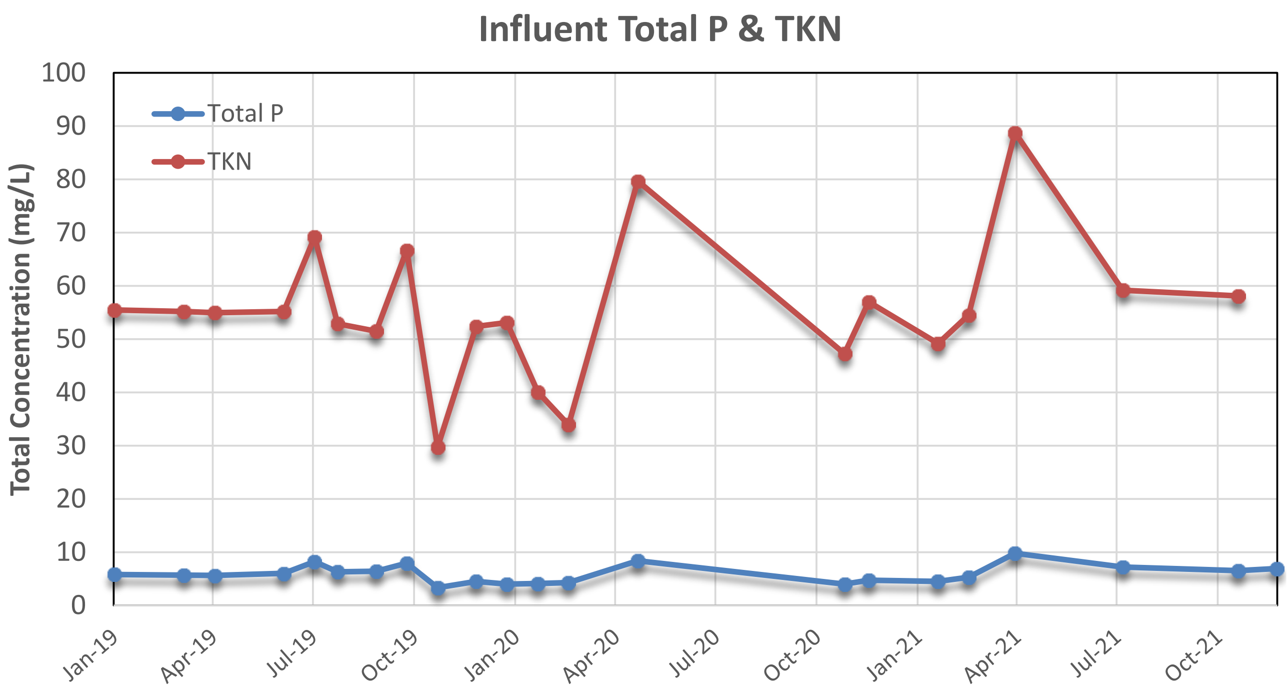


Figure 2-6: Influent P and TKN concentrations.

The lagoon system provides good ammonia removal (i.e. reduction of ammonia to nitrates and nitrites via nitrification), but minimal total nitrogen removal. In other words, effluent ammonia is very low (typically less than 1 mg/L), while effluent total nitrogen ranges from 8.0 to 25.2 mg/L. This is expected as the lagoons are not intended to remove nitrogen. The current permit has a maximum ammonia effluent concentration of 3.2 mg/L; no limit for total nitrogen exists. Based on the City's intent to use treated wastewater as Type I reuse water, total nitrogen limits will likely not dictate treatment design. Ammonia removal (via nitrification) will continue to be a major design consideration for any WWTP expansion, and protection of downstream discharge points by minimizing total effluent nitrogen removal (via denitrification) should be considered. Most modern activated sludge processes include steps for total nitrogen removal. Effluent nutrient concentration data is summarized in Figure 2-7.

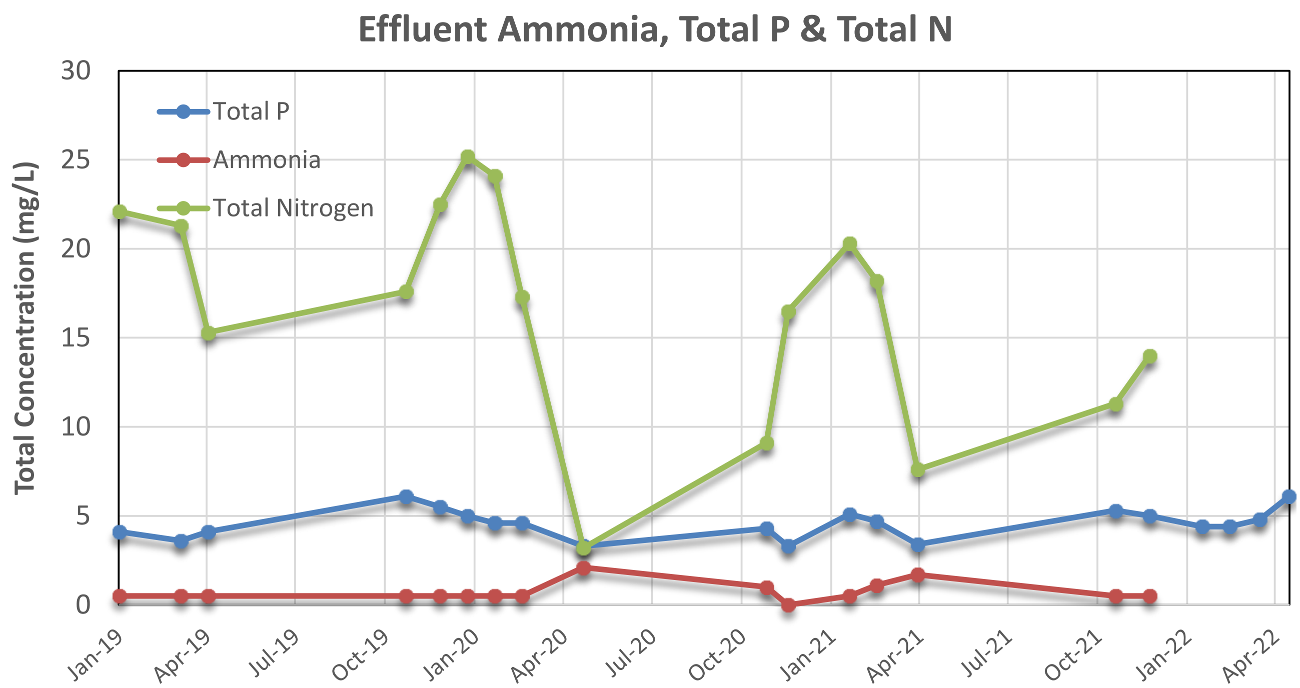


Figure 2-7: Effluent nutrient concentrations.

As noted in the effluent data, the lagoon system is not designed to provide significant phosphorous removal. The 2019 permit included an *annual* total effluent P limit of 2,839 lbs. (equivalent to 7.78 lbs. per day). Typical effluent P average 3.7 mg/L, which would limit the lagoons' capacity to 0.25 MGD. Pond evaporation and strategic timing of discharge to align with periods of lower effluent P concentrations have allowed operators to treat 0.5+ MGD without exceeding this annual limit. However, as flow continues to increase, operators can no longer reliably meet this requirement. At current flows, the plant is on track nearly double the allowed effluent phosphorus limit. Addition of alum (aluminum sulfate) is needed to reduce effluent phosphorus from 3.7+ mg/L to ~0.5 mg/L to meet permit requirements at 1.5 MGD. Even at current flows, chemical addition is required to reduce effluent concentrations to ~0.9 mg/L. Levels below 1 mg/L would be difficult to reliably achieve in a lagoon system.

Details regarding methods for chemical injection, mixing, and their impacts on lagoon operation are discussed in Section 3.6. In summary, chemical storage, dosing pumps, and mixing equipment would be required to implement chemical phosphorus removal. Annual chemical costs would range from $50,000 to over $200,000 (depending on flow rates), and the resulting sludge would significantly increase the frequency of solids/sludge dredging required in the lagoons.

A new, mechanical treatment plant would most likely include a permit effluent P limit of 1 mg/L, namely a concentration-based, rather than total-load based limit. Conversations with State permitting staff indicates that changing/increasing the lagoon's loading limit is very unlikely, even though the limit represents an effluent concentration that is lower than typical for mechanical plants. This reason alone strongly favors installation of a new WWTP rather than utilizing or expanding the capacity of the lagoons. Treatment alternatives are discussed in Chapter 3.

In summary, we recommend a design influent TKN value of 55 mg/L and a design influent total P value of 6.0 mg/L. At a 3 MGD design, this equals 1,376 lbs. ammonia and 150 lbs. of P per day. For effluent requirements, any future WWTP should continue to target complete ammonia removal (e.g. effluent ammonia targeting < 1.0 mg/L), and effluent total P less than 1.0 mg/L. If the lagoons are to be utilized in the future, their capacity should be limited to 1 MGD due to practical limits of chemical addition/P removal. Target effluent total P for the 1 MGD sent to the ponds should be less than 0.9 mg/L, and design total effluent P for any new mechanical plant addition/expansion should be less than 1.0 mg/L. For a new mechanical plant, effluent P less than 1 mg/L can be achieved biologically or chemically with biological removal (via anaerobic basins) the recommended alternative.

2.1.5 Solids Handling and Dewatering

The lagoon system does not incorporate any solids handling, dewatering, or disposal beyond long-term deposition and breakdown in the lagoons themselves. This strategy has worked well enough to date. However, with increasing flows/loading, sludge accumulation has accelerated. The first two lagoons have significant solids buildup. Several exposed islands of sludge are noted in the first pond, with large, submerged deposits continuing to grow in the second pond. If alum is added to improve phosphorus removal, sludge will accumulate even faster. Dredging of the ponds is required if they are to continue treatment service. Even if they are decommissioned and abandoned or utilized for effluent/reuse water storage, the remaining biosolids will eventually need to be removed.

Mechanical plants incorporating activated sludge processes also produce solid waste that, combined with other organic and inorganic solids removed in clarifiers, are collectively known as sludge. Sludge is periodically removed (wasted) from the clarifiers and biological treatment basins where it can be dewatered and disposed. The lagoon system does not have any sludge handling or dewatering equipment; this equipment would need to be installed as part of a mechanical plant upgrade. Alternatives for solids handling are discussed in the design alternatives in the next chapter.

2.2 Recommended Design Criteria Summary

As discussed above, we propose the following design criteria to guide expansion and upgrades to the WWTP:

- Service Population: 45,543 (2042)
- Service Connections (ERCs) ERCs: 15,181
- Average Daily Flow (ADF): 3.0 MGD
- Peak Hour Flow (PHF): 7.0 MGD
- Influent BOD: 250 mg/L (6,255 #/day)
- Influent TSS: 250 mg/L (6,255 #/day)
- Influent TKN: 55 mg/L (1,376 #/day)
- Influent Total P: 6.0 mg/L (150 #/day)

Regarding effluent quality, our understanding is that the City intends to treat effluent to Type I reuse standards. Following is a summary of Type I reuse requirements:

- BOD ≤ 10 mg/L
- Turbidity ≤ 2 NTU (daily); always < 5 mg/L
- E. Coli non-detect (daily); always < 9 MPN/100 mL

Nutrient limits are not typical for reuse water permits. However, unless the City has sufficient storage and distribution infrastructure to utilize all effluent as reuse water without requiring any discharge, effluent should be treated to meet nutrient limits. The WWTP should be designed to achieve effluent nutrient limits to give operators the ability to discharge to the ditch. Accordingly, we anticipate the following effluent nutrient limits:

- Ammonia < 1 mg/L
- Total Nitrogen < 10 mg/L
- Total P < 1 mg/L (for new mechanical processes)
- Total P < 0.9 mg/L (for lagoon effluent up to 1 MGD)

These design criteria are used to size the alternatives discussed in the next chapter. Cost estimates for installation (capital expenses), and long-term operational and maintenance costs (O&M) were developed using the criteria presented here.

CHAPTER 3 - RECOMMENDED WWTP UPGRADES & IMPROVEMENTS

This chapter discusses the upgrade and improvement alternatives for the WWTP to properly treat the projected flow and loading discussed in Chapter 2. The capacity of the existing plant is considered along with alternatives to increase capacity and performance to meet the established design criteria. The existing facility does not have capacity to treat 3 MGD and the associated loading. Thus, additional facilities will need to be installed to increase capacity. The City may elect to continue utilizing the lagoons for some treatment, building new facilities capable of handling 2 MGD. Conversely, the City could replace the lagoon system with an all-new, 3 MGD facility, potentially using the lagoon footprint for effluent (reuse water) storage and/or sludge drying and storage.

There are dozens of upgrade alternatives that could meet the City's needs. Several technologies were explored, and city staff (including plant operators) visited multiple wastewater plants throughout northern Utah to better understand the nuances, pros, and cons of each technology. Viable alternatives depend on many factors including the intended discharge/disposal method (i.e. Type I reuse, Type II reuse, or discharging to the ditches), whether the technology would be operated in parallel with the existing lagoons (or completely replace the lagoons), and which technologies best fit the size and demands of the application.

Technologies considered include oxidation ditches (e.g. Evoqua Orbal Discs, Envirodyne's brush rotors, WesTech Landy surface agitators, Aeration Industries Aire-Injectors, etc…); fine-bubble diffusers; STM Aerotors (aka hybrid fixed film reactors); membrane bioreactors (MBR); and sequence batch reactors w/ aerobic granules (aka Aquanerada). Each of these alternatives can be paired with different primary treatment (e.g. screening, primary clarifiers), technologies for disinfection, processes for solids handling, among other options. Some alternatives require additional tertiary filtration to achieve Type I reuse, while others (e.g. MBRs) do not. In addition, each technology impacts the design of downstream disinfection and solids handling processes (e.g. digestion, and type/volume of solids to be dewatered). The scope of this study is to assist the City in identifying the most viable alternatives, focusing on the four most favorable options as determined by Aqua and City staff. Accordingly, with the City's intent to reuse effluent as Type I, along with operators input and preferences as to their preferred treatment technologies, four preferred alternatives were identified. After multiple workshops with City staff, the following four alternatives detailed in this study are:

1) **Oxidation Ditches** (surface aeration) utilizing Evoqua Orbal Discs. This option requires a new headworks (screens/grit removal), anaerobic tanks (for P removal), oxidation ditches, recirculation pumps, secondary clarifiers, tertiary filtration (for Type I reuse), disinfection, and sludge dewatering. Other surface aeration technologies would be similar in cost and scope to this analysis, but the Orbal discs were the City's preferred technology for this option.

2) **Fine-Bubble Diffusers** This option requires a new headworks (screens/grit removal), anaerobic tanks (for P removal), anoxic tanks (for nitrogen removal), aeration basins, blowers, recirculation pumps, secondary clarifiers, tertiary filtration (for Type I reuse), disinfection, and sludge dewatering. This analysis is based on EDI equipment, but multiple manufacturers of similar equipment are available.

3) **MBR** This option requires a new headworks (screens/grit removal), anaerobic tanks (for P removal), anoxic tanks (for nitrogen removal), aeration basins, MBR tanks, blowers, permeate pumps, chemical cleaning equipment, disinfection, and sludge dewatering. This analysis is based on Suez membrane cassettes.

4) **Parallel Lagoon and Fine-Bubble Diffusers** would split flow, sending 1 MGD to the lagoons and 2 MGD to a new fine-bubble diffuser process. This option requires a new headworks that would serve both the lagoons and diffuser process. The fine-bubble diffusers would have the same requirements as Item #2, at a smaller (2/3rds) scale. In addition, the lagoons would need to be rehabilitated to extend their service life including repairs to diffusers, blower rebuilds, replacement of biocurtains, and additional electrical to render all surface aerators operable. The lagoons would also need chemical addition and mixing to improve P removal. Note that in this option, it assumed that lagoon effluent

would not be utilized as Type I water, as it is difficult to properly filter lagoon effluent sufficiently.

Regardless of the selected alternative, the existing lagoon system as currently installed is approaching its practical capacity, and already exceeding its effluent P limit. Consequently, some additional capacity will need to be installed, whether or not the City elects to continue operating the lagoons. The following sections detail preliminary process configurations, cost estimates, estimated O&M costs, and calculate an equivalent 20-year net present value (NPV) for the four selected alternatives. The pros and cons of each alternative are also summarized within each section. Recommendations and timing are discussed in Chapter 4.

Finally, these alternatives are assumed to be installed at the existing WWTP site. However, the cost estimates provided herein would be comparable regardless of whether the existing site or a new location is selected. Only the fourth alternative, which uses the existing lagoons, would be impacted and impractical if the WWTP is relocated. Site selection and location is not a primary focus of this study as it does not play a major role in sizing of the WWTP or technology selection. However, some preliminary discourse on the impacts of relocating the plant are summarized in Chapter 4 for reference.

3.1 Overview of Major Treatment Processes

Each alternative addresses the major processes and equipment necessary to treat wastewater to meet permit requirements. Alternatives can include a headworks building, secondary biological process, clarification (if applicable), tertiary filtration (if applicable), disinfection, and solids handling. Details of each major process are specific to the alternatives, but all serve similar purposes, summarized as follows:

3.1.1 Headworks

The headworks serves as the first step in treatment to remove large and/or heavy inorganic material from the waste stream that cannot be treated biologically. Target removal includes large, solid debris, rags, hair, grit, and sand. Headworks consist of screens and grit removal chambers.

Screened materials and settled grit are washed to return organic material back to the waste stream. Remaining inorganic material is compacted and collected for disposal. Different processes require different levels of removal efficiency and allowable debris passage as detailed in the various alternatives below.

3.1.2 Secondary Biological Processes

All secondary biological process discussed in this study utilize activated sludge (i.e. specialized bacteria) to remove nutrients and organic compounds (collectively called BOD) from the wastewater. The activated sludge is recycled through the system (as RAS) and clarifiers (or membranes) keep solids in the waste stream while allowing clean and clear water to proceed to disinfection and/or tertiary filtration. These processes provide mixing and ideal environments for target bacteria to achieve wastewater treatment as follows:

- **Anaerobic Basins**: Anaerobic basins are volumes with no dissolved oxygen (DO) and little to no available oxygen in other forms such as nitrate/nitrite. Anaerobic basins facilitate biological phosphorus removal by encouraging specialized bacteria known as phosphorous accumulating organisms (PAOs) to release volatile fatty acids (VFAs). These acids, combined with a carbon and oxygen rich aerobic environment later in the process stream, encourage net phosphorus uptake in the cell structure of the PAOs. The bacteria are collected in secondary clarifiers (or filtered with membranes) and eventually wasted from the system as waste activated sludge (WAS). In other words, the anaerobic chambers prepare bacteria and conditions to provide a net reduction in orthophosphate, ultimately reducing effluent phosphorus levels.

  Through biological nutrient removal, phosphorous can typically be reduced to less than 1 mg/L (Metcalf, 2003; MPCA, 2006). Anaerobic basins are sized based on hydraulic retention time (HRT), with a minimum of one hour recommended to achieve efficient phosphorous removal. HRT's in excess of three hours are also not desirable as prolonged exposure to the environment can cause the phosphorus to release back into the influent waste stream. Thus, ideally the basin provides a minimum of one hour HRT during peak flow events, while preventing HRT's of more than three hours during normal flow. The basins are equipped with mixers to keep the mixed liquor in suspension.

- **Anoxic Basins**: Anoxic basins are tanks with no DO, but oxygen is available in other forms such as nitrate and nitrite. Anoxic basins utilize specialized denitrifying bacteria that strip oxygen from various nitrous oxide molecules (NO_3, NO_2, NO, N_2O, etc…), returning some oxygen back to the wastewater stream and releasing nitrogen as N_2 gas to the atmosphere. The result is a reduction in the overall total effluent nitrogen. Requirements for anoxic basins are based on multiple factors including minimum design water temperatures, mixed liquor suspended solids (MLSS) concentration, and other site-specific operating parameters. These basins require internal recycle from the aeration basin effluent to supply nitrate as an oxygen source. Note that ammonia must first be nitrified in the aeration basin prior to denitrification. Anoxic basins also require mixing to maintain solids in suspension. Finally, some of the oxygen that is stripped from oxygen bearing NO_x molecules results in a net oxygen credit of ~2.6 #O_2/#NO_3 denitrified back to the system that can reduce the overall oxygen demand in the aeration basins.

- **Aeration Basins**: Aeration basins provide oxygen to the system allowing bacteria to breakdown and reduce carbon and BOD demand in the waste stream. Nitrifying bacteria are also present and require carbon, alkalinity, and oxygen to nitrify ammonia, ultimately converting it to nitrate (NO_3). Oxygen can be introduced in multiple manners. This study includes surface aeration (oxidation ditches) and fine-bubble diffusers as methods for entraining oxygen into the waste stream. These technologies also provide mixing in the aeration tanks to keep solids in suspension.

  Typical design requires 1.2 pounds of oxygen (O_2) per pound of BOD removed and 4.6 pounds of oxygen per pound of ammonia (NH_3) converted into nitrates (NO_x). Thus, the 6,255 # BOD/day and 1,376 # NH_3/day established require 7,500 and 6,330 pounds of DO respectively, for a total design oxygen demand of 13,830 # O_2/day. This value will be used to size the new aeration basins in the alternatives below. Aeration basins are sized based on the required footprint and sludge retention time (SRT) and are dependent on specific equipment supplier's requirements.

- **Secondary Clarifiers**: Most activated sludge processes require secondary clarifiers to collect activated sludge to be recycled back to the biological process as RAS. Processes such as MBR use membranes to filter out solids and sludge without clarification. Secondary clarifiers also sufficiently remove suspended solids well enough to meet most non-reuse applications. Where low TSS and turbidity levels are necessary, additional (tertiary) filtration is required. Secondary clarifiers are sized to maintain surface overflow rates at or below 500 gallons per square foot per day (MetCalf, 2003).

3.1.3 Tertiary Filtration & Disinfection

Where TSS levels less than 10 mg/L and low turbidity are required, additional filtration beyond secondary clarification may be necessary. For Type I reuse, tertiarily filtration would be required for oxidation ditch and fine bubble diffuser plants. MBR plants do not require tertiary filtration. Filtration can be provided with sand filters or more compact rotating disc filtration units. Most modern installations install disc filters as they have a much smaller footprint and are easier to operate. Disc filtration is offered by many suppliers, with costs and options dependent on effluent requirements and the upstream technology.

Disinfection of wastewater is normally achieved with either chlorination or UV disinfection. Both work and have their advantages. The MBR or tertiary filtration effluent (required for Type I reuse) will have very high transmissivity, making UV disinfection an efficient and preferable alternative. As the City currently utilizes and is generally comfortable with UV disinfection, all alternatives discussed herein assume expansion with UV disinfection. No intriguing advantages of switching to a chlorination disinfection system were identified in our review.

UV disinfection can be installed as an open channel, gravity system, or in closed vessels (which typically require pumping or sufficient head in the system to push through the vessels. MBR systems normally incorporate closed vessel UV as membrane effluent is pumped from the membranes with permeate pumps, meaning sufficient head to flow through the vessels is inherently available. Oxidation ditch and fine bubble diffuser options are assumed to incorporate open channel UV disinfection.

3.1.4 Solids Handling

All activated sludge processes yield a net solids load that must be regularly wasted from the system. For processes with secondary clarifiers, RAS settles and is collected in the clarifiers and pumped back to the front of the biological process. For MBR plants, RAS is pulled directly from the mixed liquor (i.e. not concentrated as settled sludge in a clarifier). Regardless, Waste Activated Sludge (WAS) is normally diverted from the Recycle Activated Sludge (RAS) flow stream. Waste sludge can be handled in many ways depending on the size and need of the installation. Larger plants may incorporate anaerobic digestion to further break down solids and reduce the volume of solids that must be dewatered and hauled/disposed. For smaller and medium sized plants, the cost and complexity of operating anaerobic digesters does not usually make sense. For this application, anaerobic digestion will not likely yield a net cost benefit for the City, and our assumption is that WAS will be pumped to small storage tank and fed directly to sludge dewatering equipment.

Sludge dewatering entails mixing polymer with sludge to improve its dewaterability. The sludge/polymer mix is sent to a dewatering machine that separates water from the sludge, usually increasing the solids content from 1-2% to 15-20%. This significantly reduces the volume (and therefore cost) of hauling solids for disposal. Depending on the space available at the site, and odor concerns of adjacent property, dewatered solids can be stored in drying beds to further remove moisture, and even composted. However, preliminary investigation and discussion with City staff indicate that the City will most likely transport dewatered solids to the closest available landfill for disposal.

Many options for sludge dewatering are available including screw presses, belt presses, fan presses, plate presses, and centrifuges. Each has particular advantageous and drawbacks. Feasible technologies are normally dictated by the size and flow/solids loading of the application. Large facilities usually incorporate belt presses or centrifuges due to their high capacity. Smaller facilities can use any technology, and existing installations of each technology on a smaller scale are readily identified. Screw presses offer a good balance of small footprint, easy operability, durability, and performance and have been successfully implemented at multiple plants comparable in size to the Grantsville WWTP. Our investigation was not exhaustive on specific dewatering technologies, but the following alternatives assume installation of screw presses for sludge dewatering. Final selection would be best served with a formal equipment procurement (RFP) process once specific design criteria from the main process elements are known.

3.1.5 Reuse Water & Effluent Storage

Finally, consideration must be given for disposal. The City may continue to discharge to the drainage ditch until reuse distribution systems are in place. However, even once a reuse distribution system is installed, reuse demand may not match the influent flow to the plant. If demand is less than effluent, some disposal is needed. During non-irrigation months (considered to be October through March), water can be discharged normally or stored if summer demand is sufficient. In other words, demand during the summer must essentially double average influent flow in order to use daily influent plus winter storage volumes. Even if demand is high enough to utilize all winter flow, normal, direct discharge may be desirable if storage capacity is reached and/or other disruptions (poor treatment quality, low demand, interruptions to the distribution system, etc.) occur.

Regarding storage, the existing site could potentially accommodate ~50 acres of storage lagoons if most of the lagoons are converted to storage ponds. At an average depth of 8 feet, this would provide ~130 million gallons of storage, or 44 days' worth at 3 MGD. Note that the lagoons would need to be dried, dredged, and otherwise prepared to serve as storage ponds. Storage for full winter flow (at least 180 days) would require 540 million gallons of storage, which would require over 200 acres of lagoon space at 8 feet depth. Even pushing storage depths to 15 feet, over 100 acres is needed. In other words, while the existing site can provide significant storage volume, more storage will be needed offsite if the City intends to fully store and utilize all wastewater as reuse water.

Storage needs should be considered when discussing relocating the plant. A larger site would provide more storage, and the existing site could still be utilized as satellite storage. Other options include pumping to a reservoir (to prevent pumping more than once and to provide flow EQ) and/or blending treated water with other irrigation sources to increase demand and minimize costs for reuse distribution.

Type I reuse is the target treatment level for the City as it can be used for any irrigation application (agricultural, parks, residential, golf courses, etc.). Type II has less stringent requirements but is limited to certain agricultural applications that must be well removed from any potential contact with the general public. Accordingly, this plan focuses on Type I requirements for treatment applications.

3.2 Existing Facilities and Capacities

Many improvements and new facilities are required regardless of the selected alternative, especially for Type I reuse water. The lagoons' theoretical capacity of 1.5 MGD is not sufficient for anticipated growth. Flow rates are estimated to reach the practical limit of 1 MGD by 2025. The lagoons are meeting all permit requirements except for effluent phosphorus. As discussed above, the lagoons cannot reliably meet effluent P levels when flows exceed 0.5 MGD without chemical addition. Following is a summary of existing facilities and their limitations.

3.2.1 Headworks

The headworks is designed for ADF up to 1.5 MGD and theoretical peak hour flows up to 3.0 MGD. However, as noted above, peak flow factors frequently exceed this flow level, overloading the headworks. This causes backup in the channels/screens, reduces the efficacy of screening and grit removal, and can impact influent flow measurement. Regardless of the selected alternative, it is recommended that a new headworks facility be installed, sized to treat peak hour flows up to 7.0 MGD. The specifics of screening and grit removal will depend on the selected downstream technology. Even if the lagoons remain in service, a new headworks should be installed to service the lagoons and new process facilities. Preliminary cost estimates for a new headworks building range from $4.5 to $5.4 million depending on the selected alternative. A breakdown of these estimate is provided in the following alternative discussion sections.

3.2.2 Lagoons

The primary treatment lagoon is equipped with submerged diffusers fed by large blowers. This lagoon also has biocurtains to provide some plug flow and improve overall BOD and ammonia reduction. The second lagoon contains five floating aerators. The third lagoon has three floating aerators, but they are not currently connected to power or controls. If the lagoons are to be utilized long-term, power and controls for these units should be installed.

Our review of the installation and conversation with operators has identified some elements that require repair or replacement if the lagoons are to be utilized for 5-10+ years. Table 3-1 provides a preliminary cost estimate for these repairs, which include:

- Addition of chemical (alum) storage, injection pumps, and mixing for improved phosphorus removal.
- Replace diffuser membranes in the primary lagoon.
- Replace biocurtains in the primary lagoon.
- Replacement of four (4) decant control valves between the primary and secondary lagoon.
- Replacement of ~500 feet of the 24" air line supplying the primary lagoon diffusers.
- Install electrical/controls for floating surface aerators in third lagoon.
- Dredge all active lagoons, especially the primary and secondary lagoons.
- Upgrade control panel for existing UV disinfection system.

Also, note that if the lagoons are not utilized for treatment, the accumulated sludge will still need to be addressed in some manner. Odors, dust, and other nuisance conditions will likely arise if the lagoons are simply bypassed and abandoned. If a new plant is installed, the lagoons will need to be dried, and accumulated solids excavated and removed from the site. This cost is estimated to be considerably less than dredging active wastewater lagoons however. The lagoons can be allowed to dry, significantly reducing the volume and weight of solids to be excavated, transported, and disposed. While past cost estimates for dredging the active lagoons approach $3 million, removing dried solids from decommissioned lagoons is estimated to cost closer to $500,000. Nonetheless, this cost is included in the capital costs and overall NPV of the alternatives that do not use the lagoons. Removal of solids would be even more crucial if the lagoons are to be utilized as effluent storage for reuse.

Table 3-1: Cost estimates for rehabilitation of existing lagoon process.

Lagoon Rehabilitation Cost Estimates		
Item	**Cost**	
Chemical Addition for P Removal	$	117,500.00
Replace Some Primary Lagoon Diffusers	$	150,000.00
Replace Primary Lagoon Biocurtains	$	160,000.00
Replace Decant Valves	$	72,000.00
Replace 24" Air Line	$	117,500.00
Install Electrical for 3rd Lagoon Aerators	$	120,000.00
Dredge Lagoons	$	3,000,000.00
Upgrade UV Disinfection Control Panel	$	65,000.00
TOTAL	**$**	**3,802,000.00**
Contingency (25%)	$	950,500.00
Engineering & Design (8%)	$	304,160.00
Construction Management (7%)	$	266,140.00
Legal & Administrative (3%)	$	114,060.00
TOTAL	**$**	**5,436,860.00**

3.2.3 Disinfection

The existing UV disinfection system is operating adequately and is sized to handle current effluent flow from the lagoons (up to 1.5 MGD). Additional disinfection capacity is needed for any expansion beyond the 1 MGD that could still be sent to the lagoons. Recommended upgrades for the existing UV control panel, necessary for its successful long-term operation, are estimated to cost $65,000 (see Table 3-1). Cost estimates for UV disinfection expansion range from $1.6 to $2.2 million depending on the scale and type of equipment selected. Details are discussed in the sections below.

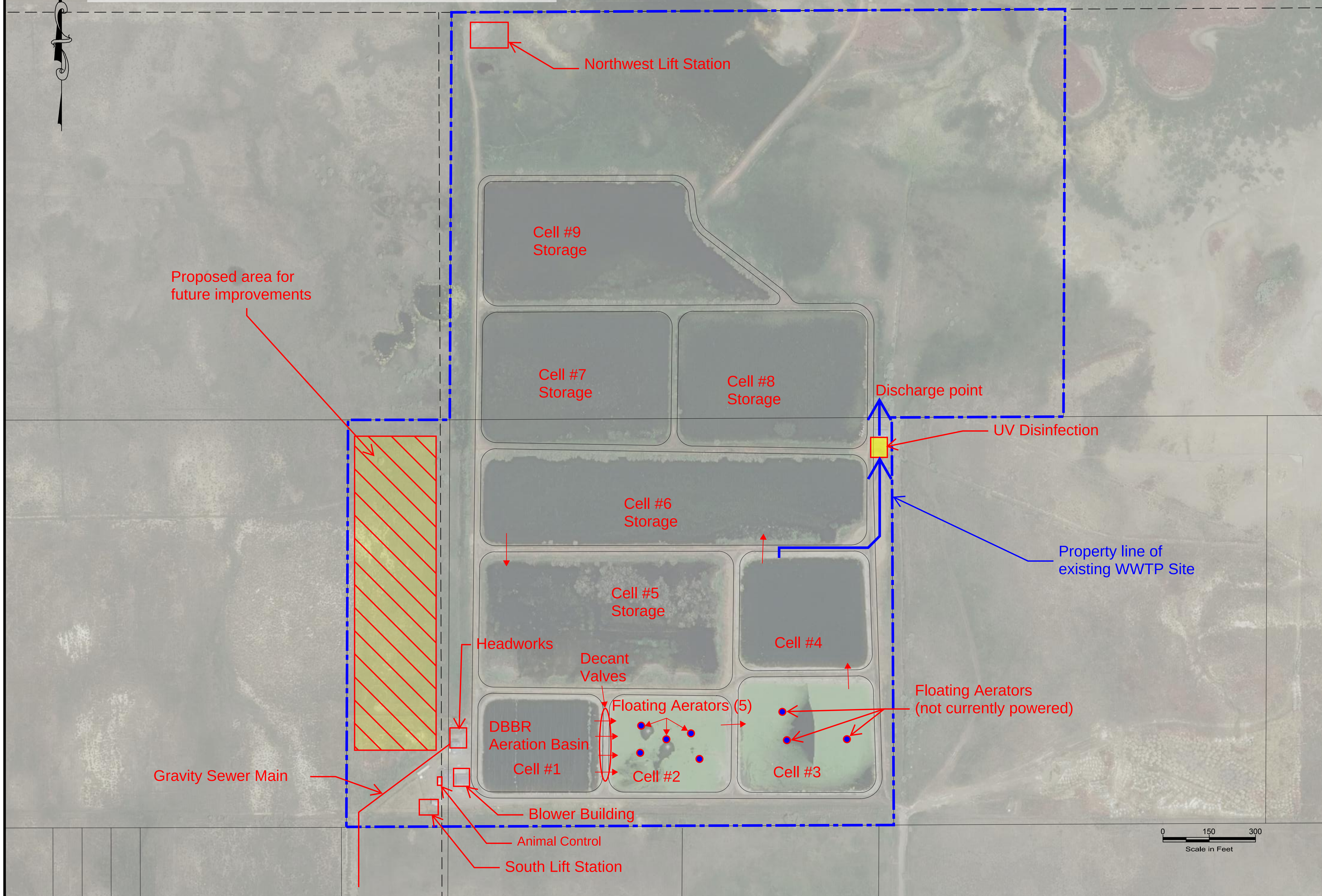
Alternative 4 (Section 3.6), includes these cost estimates for expansion that uses the lagoons in parallel (at 1 MGD) with a new 2 MGD activated sludge process.

Lastly, any WWTP expansion will require increased capacity and improved logic/controls of the influent pump station regardless of the selected technology. The cost is the same for all alternatives discussed here (Table 3-2). A site plan showing the existing WWTP and major improvements discussed here is provided in .

Table 3-2: Cost estimates for upgrading the influent pump station.

Influent Pump Station Expansion	
Item	**Cost**
Pumps	$ 200,000.00
Concrete	$ 550,000.00
Mechanical/Piping Installation	$ 230,000.00
Site/Civil Work	$ 75,000.00
Electrical, Controls & Instrumentation (20%)	$ 211,000.00
Subtotal	**$ 1,266,000.00**
Contingency (25%)	$ 316,500.00
Engineering & Design (8%)	$ 101,280.00
Construction Management (7%)	$ 88,620.00
Legal & Administrative (3%)	$ 37,980.00
TOTAL	**$ 1,810,380.00**

Figure 3-1: Grantsville WWTP existing site and lagoons.



DRAWING IS TO SCALE IF BAR MEASURES: 1" = FULL SCALE 1/2" = HALF SCALE

0 1/2 1

ORIGINAL				
NO.	DATE	DESIGN	DRAWN	CHECKED
0	-	-	-	-

REVISIONS

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6/3/2022

3.3 Alternative 1 – Oxidation Ditch

This alternative would require a new headworks building, an anaerobic tank (with mixing) for phosphorous removal, oval-shaped oxidation ditches, secondary clarifiers, tertiary filtration, and UV disinfection. The headworks would incorporate ¼" (6 mm) fine screens and grit removal. A preliminary cost estimate for the headworks is provided in Table 3-3. The headworks building would be roughly 50-foot square, and sufficiently tall to house and allow access/removal of screening and grit removal equipment. Washpactors for screenings, grit pumps, and grit classifier/washers would all be housed in the headworks building. Odor control is not required, but is frequently installed with headworks buildings.

Table 3-3: Headworks building cost estimate.

Headworks Building - 6mm Screens	
Item	**Cost**
Influent Screens Equipment	$ 460,000.00
Grit Removal Equipment	$ 637,500.00
Odor Control	$ 115,000.00
Mechanical/Piping & Installation	$ 300,000.00
HVAC	$ 120,000.00
Headworks Building	$ 575,000.00
Channel/Grit Removal Concrete Work	$ 200,000.00
Yard Piping	$ 150,000.00
Site/Civil Work	$ 120,000.00
Electrical, Controls & Instrumentation (20%)	$ 535,500.00
Subtotal	**$ 3,213,000.00**
Contingency (25%)	$ 803,250.00
Engineering & Design (8%)	$ 257,040.00
Construction Management (7%)	$ 224,910.00
Legal & Administrative (3%)	$ 96,390.00
TOTAL	**$ 4,594,590.00**

Oxidation ditches use surface aeration, or entrainment of oxygen into wastewater by agitating the surface of the water, to provide oxygen for BOD removal and nitrification of ammonia. Oxidation ditches include aerobic and anoxic zones, meaning the tanks provide nitrification and denitrification in addition to BOD removal. A separate anaerobic tank (with mechanical mixer) preceding the oxidation ditch is required for phosphorus removal. RAS from the secondary clarifiers is returned to the anaerobic tank where it mixes with raw influent from the headworks prior to entering the oxidation ditch.

The overall footprint of the oxidation ditch is 210-feet by 140-feet, with an operating depth of 14.5 feet. The Orbal system consists of three rings, each 20-feet wide, with flow entering the outer ring and flowing towards the inner ring. Net overflow from the inner ring passes over a weir and continues on to secondary clarifiers. Each ring is equipped with three drive motors powering shafts equipped with multiple discs. The disc surface is textured, creating sufficient agitation to entrain oxygen. The outer most volume is large, and oxygen demand is high, so anoxic conditions develop between the disc/aeration zones to provide denitrification. Internal recycle (IR) from the interior ring back to the exterior ring is required for complete denitrification. Internal recycle rates range from 1 to 4 Q (i.e. 1 to 4 times the ADF), and typically operate at 3-4 Q. Thus, IR pumps would need to be sized to provide up to 12 MGD. A preliminary cost estimate for the anaerobic tank and oxidation ditch is provided in Table 3-4.

Table 3-4: Cost estimate for oxidation ditch secondary process.

Orbal Oxidation Ditch	
Item	**Cost**
Anaerobic Basin Concrete	$ 425,000.00
Anaerobic Basin Mixing Equipment	$ 40,000.00
Orbal Aeration Equipment Package	$ 1,300,000.00
Orbal Ditch Concrete	$ 3,050,000.00
Recirculation Pumps	$ 70,000.00
Mechanical Installation	$ 230,000.00
Site/Civil Work	$ 220,000.00
Electrical, Controls & Instrumentation (20%)	$ 1,067,000.00
Subtotal	**$ 6,402,000.00**
Contingency (25%)	$ 1,600,500.00
Engineering & Design (8%)	$ 512,160.00
Construction Management (7%)	$ 448,140.00
Legal & Administrative (3%)	$ 192,060.00
TOTAL	**$ 9,154,860.00**

Effluent from the oxidation ditch flows through secondary clarifiers to collect sludge to be returned to the ditch as RAS and clarify water prior to final filtration and disinfection. For this application, two (2) 90-foot diameter clarifier tanks are recommended. Installation includes concrete tanks, the clarifier mechanisms, RAS pumps, and associated piping; costs are summarized in Table 3-5.

Table 3-5: Cost estimates for 90-foot diameter secondary clarifiers.

Secondary Clarifiers	
Item	**Cost**
(2) Clarifier Concrete Structures	$ 2,000,000.00
(2) Clarifier Mechanisms	$ 740,000.00
RAS/WAS Pumps	$ 50,000.00
Mechanical Installation	$ 50,000.00
Site/Civil Work	$ 150,000.00
Electrical, Controls & Instrumentation (10%)	$ 299,000.00
Subtotal	**$ 3,289,000.00**
Contingency (25%)	$ 822,250.00
Engineering & Design (8%)	$ 263,120.00
Construction Management (7%)	$ 230,230.00
Legal & Administrative (3%)	$ 98,670.00
TOTAL	**$ 4,703,270.00**

For Type I reuse, secondary clarifier effluent needs additional filtration to meet TSS and turbidity requirements. Though Type I effluent may not always be required (e.g. in winter months when sufficient demand or storage is not available), the system must be sized to handle typical ADF and PHF. If winter storage is utilized, the system may need to be even larger if filtration of stored water is required (i.e. to handle influent flow plus pond storage water). Regardless, disc filters are normally installed indoors (especially where cold weather is expected). The disc filter units normally consist of tank (either concrete or self-standing stainless steel) that houses discs. The discs are rotated by a drive motor, and each unit is equipped with backwash pumps to clean the disc media. A preliminary cost estimate for this application is provided in Table 3-6.

Table 3-6: Cost estimates tertiary filtration.

Tertiary Disc Filtration	
Item	**Cost**
Disc Filter Equipment Package	$ 847,000.00
Equipment Room	$ 250,000.00
Mechanical Installation	$ 100,000.00
Site/Civil Work	$ 40,000.00
Electrical, Controls & Instrumentation (20%)	$ 247,400.00
Subtotal	**$ 1,484,400.00**
Contingency (25%)	$ 371,100.00
Engineering & Design (8%)	$ 118,752.00
Construction Management (7%)	$ 103,908.00
Legal & Administrative (3%)	$ 44,532.00
TOTAL	**$ 2,122,692.00**

Disinfection follows final filtration prior to discharge or distribution as reuse water. As flow will likely gravity flow through the plant, an open channel UV system is assumed for this alternative. UV equipment is normally installed indoors where feasible, and can share building space with tertiary filtration in non-corrosive environments when practical. Preliminary estimates using Trojan Signa units recommend a dose from 80 to 100 mJ/cm^2 for Type I reuse depending on the design UV transmissivity (UVT). This particular system would include seven total banks, six duty with 1 standby. UV systems have good turndown capabilities, so if lower dosing is desired during non-irrigation season, the dose rate could potentially be reduced to save energy. Preliminary cost estimates to install this UV system are summarized in Table 3-7.

Table 3-7: Cost estimates for open channel UV disinfection.

UV Disinfection	
Item	**Cost**
UV Equipment Package	$ 800,000.00
Equipment Room	$220,000
Mechanical Installation	$ 115,000.00
Site/Civil Work	$ 55,000.00
Electrical, Controls & Instrumentation (20%)	$ 238,000.00
Subtotal	**$ 1,428,000.00**
Contingency (25%)	$ 357,000.00
Engineering & Design (8%)	$ 114,240.00
Construction Management (7%)	$ 99,960.00
Legal & Administrative (3%)	$ 42,840.00
TOTAL	**$ 2,042,040.00**

Lastly, WAS must be mixed with polymer and dewatered prior to hauling and disposal. A preliminary cost utilizing Huber S - Screw Press units is provided in Table 3-8. Normally, sufficient dewatering units are installed to allow all dewatering to occur during normal operation hours, assumed to be over a 5-day/40-hour work week. Table 3-9 is a summary of the total capital cost estimate for this alternative.

Table 3-8: Cost estimates for sludge dewatering process.

Sludge Dewatering	
Item	**Cost**
Dewatering Equipment	$ 970,000.00
Polymer Equipment	$ 20,000.00
Mechanical Installation	$ 125,000.00
Equipment Room	$ 450,000.00
Site/Civil Work	$ 60,000.00
Electrical, Controls & Instrumentation (20%)	$ 325,000.00
Subtotal	**$ 1,950,000.00**
Contingency (25%)	$ 487,500.00
Engineering & Design (8%)	$ 156,000.00
Construction Management (7%)	$ 136,500.00
Legal & Administrative (3%)	$ 58,500.00
TOTAL	**$ 2,788,500.00**

Table 3-9: Total capital cost estimate for oxidation ditch alternative.

CapEx Cost Summary	
Oxidation Ditch Process	
Item	**Cost**
Influent Pump Station	$ 1,810,380.00
Headworks	$ 4,594,590.00
Oxidation Ditch Process	$ 9,154,860.00
Secondary Clarifiers	$ 4,703,270.00
Tertiary Filtration	$ 2,122,692.00
Disinfection (UV)	$ 2,042,040.00
Sludge Dewatering	$ 2,788,500.00
Dredge Old Lagoons	$ 500,000.00
TOTAL	**$ 27,716,332.00**

Operation and maintenance costs associated with this alternative include power requirements for drive motors, replacement of major wear components, and some chemical/polymer use for sludge dewatering. Power costs are estimated assuming an average cost of $0.12 per kilowatt hour. Energy demand is calculated by multiplying the average power draw of each drive motor by its anticipated run time. Power is required for operating headworks equipment, though this cost is small relative to the oxidation ditch drive motors and disinfection. Large power demand includes the drive motors for the discs with three (3) 40-HP drives and three (3) 75-HP drives. Internal recycle and RAS pumps have some power draw as well. Secondary clarifier drive motors are small (1 to 2 HP typically) and therefore have small operating costs.

Tertiary filtration power demand is also small as drive motors are not large and backwash pumps are likewise relatively small and only operate periodically. UV disinfection has a high-power demand which depends on the flow rate and the UVT of influent water. Lower UVT requires more power to disinfect an equivalent flow to the same level. Solids dewatering power demand is relatively small; WAS pumps (if required) are small (< 10 HP normally) as are the drive motors for polymer pumps, polymer mixing, and the dewatering mechanism itself (0.5 – 2 HP). Solids conveyors also have smaller drive motors (1-2 HP).

Replacement of major wear components and additional operator time/effort to deal with replacement are the other major considerations for O&M costs. For the headworks, screens usually require occasionally replacement of brushes, rollers, chains, sprockets, lamella, and other components every 3-5 years depending on use. Washpactors and grit classifiers can require occasional replacement of liners or moderate rebuilds over their lifetime.

The Evoqua Orbal system requires rebuild of drive motors, replacement of shaft couplers and bearings, and replacement of worn or broken discs over its service life. Secondary clarifiers do not typically require major rebuilds or repairs as long as they are property maintained, tested, and regularly inspected to prevent major wear. Disc filters require occasionally replacement of disc/filter media over their service life. UV disinfection has regular wear items such as lamps, quartz sleeves, and ballasts. UV lamps typically have an average service life of 12,000 hours. Finally, screw press units can require occasionally brush replacement. Polymer is another significant annual expense that must be accounted for. Table 3-10 provides a breakdown of the O&M cost estimates for this alternative. A 20-year NPV comparison is discussed at the end of this chapter.

Table 3-10: Summary O&M costs for oxidation ditch alternative.

Oxidation Ditch Option (Based on Evoqua System)						
ESTIMATED OPERATION, MAINTENANCE, AND REPLACEMENT COSTS						
Description	**Qty (Active)**	**Power per unit, hp**	**Power per unit, kW**	**Operation Time, hrs per day**	**Total Cost/day**	**Total Cost/Year**
HEADWORKS						
Influent Screen	2	2	1.5	6	$ 2	$ 800
Grit Trap Mechanism	1	1	0.7	24	$ 2	$ 800
Grit Pump	1	10	7.5	6	$ 5	$ 2,000
Classifier	1	1.5	1.1	4	$ 1	$ 200
Major Wear/Maintenance Parts						
Screen Brush, Bearings, Etc.						$ 2,502
Grit Equipment						$ 1,000
Labor						
Labor						$ 8,448
SECONDARY TREATMENT						
Anaerobic Basin Mixers	2	6	4.5	24	$ 26	$ 9,400
Oxidation Ditch - Outer Drives	3	40	29.8	24	$ 258	$ 94,100
Oxidation Ditch - Inner Drives	3	75	56.0	24	$ 483	$ 176,400
Internal Recycle Pumps	2	10	7.5	24	$ 43	$ 15,700
RAS Pumps	2	10	7.5	24	$ 43	$ 15,700
Secondary Clarifier Mechanisms	2	1	0.7	24	$ 4	$ 1,600
Major Wear/Maintenance Parts						
Drive Motors						$ 4,800
Couplings/Bearings/Lubricators						$ 12,000
Replacement Disks						$ 6,250
Labor						
Labor						$ 6,996
TERTIARY FILTRATION						
Filter Drive & Backwash Pumps	Annual Power Consumption Estimate					$ 3,288
Major Wear/Maintenance Parts						
Filter Cassettes						$ 4,500
Labor						
Labor						$ 132
DISINFECTION						
UV Disinfection Modules	3	-	16	24	$ 138	$ 50,500
Major Wear/Maintenance Parts						
UV Lamps						$ 12,000
UV Ballasts						$ 455
Labor						
Labor						$ 2,376
SOLIDS HANDLING						
WAS Pumps	2	15	11.2	8	$ 21	$ 7,800
Screw Press Units	1	5	3.7	8	$ 4	$ 1,300
Polymer Pumps	1	0.5	0.4	8	$ 0	$ 100
Solids Conveyor	2	5	3.7	8	$ 7	$ 2,600
Major Wear/Maintenance Parts						
Brush Replacement						$ 1,250
Chemical/Labor						
Polymer						$ 22,500
Labor						$ 1,173
					Total	$ 468,670

Oxidation ditches are relatively less complex to operate compared to other activated sludge processes. There are fewer wear components (drive motors, bearings, couplers, and potentially brushes or discs), and the large volume is more robust and forgiving regarding upsets and variations in wastewater consistency. Oxidation ditches have been utilized for decades with little changes to equipment or operations. They have large footprints and are not as flexible with regards to expansion and sizing as other technologies. The surface aeration approach is typically not as energy efficient as fine-bubble diffusers or other entrainment methods. A summary of pros and cons:

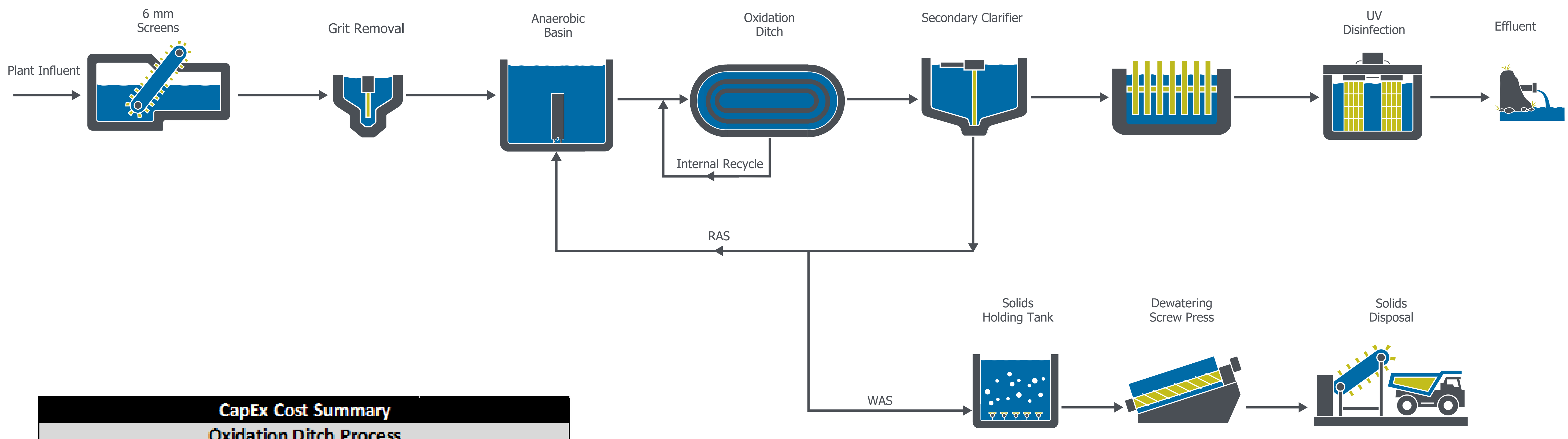
***Pros**:*

- Simple operation and less wear/maintenance components relative to other activated sludge processes.
- Process can be more forgiving and flexible in terms of operating conditions and potential upsets.
- Dedicated anoxic tanks are not typically required.
- No auxiliary equipment such as blowers that require additional building footprint.
- Established technology with decades of operational experience and refinement available for research.

***Cons**:*

- Large footprint and more concrete required compared with other options, resulting in higher construction costs.
- Due to large basin size and geometry, less convenient to scale, expand, or provide true redundancy.
- Surface aeration is less energy efficient compared to other technologies.

A process flow diagram is provided in Figure 3-2 for reference.



CapEx Cost Summary	
Oxidation Ditch Process	
Item	**Cost**
Influent Pump Station	$ 1,810,380.00
Headworks	$ 4,594,590.00
Oxidation Ditch Process	$ 9,154,860.00
Secondary Clarifiers	$ 4,703,270.00
Tertiary Filtration	$ 2,122,692.00
Disinfection (UV)	$ 2,042,040.00
Sludge Dewatering	$ 2,788,500.00
Dredge Old Lagoons	$ 500,000.00
TOTAL	**$ 27,716,332.00**

Figure 3-2: Oxidation ditch process flow diagram.

3.4 Alternative 2 – Fine Bubble Diffusers

The fine bubble diffuser alternative includes a new headworks building, nutrient removal basins (anaerobic and anoxic), aeration (fine bubble diffuser) basins, internal recycle pumps, blowers (and associated building), secondary clarifiers, tertiary filtration, UV disinfection, and solids handling equipment. Many of these facilities are very similar or identical to those discussed for the oxidation ditch alternative. The headworks building for example is equal to that described in Section 3.3, with a total cost estimate of $4,594,590 as summarized in Table 3-3.

The biological nutrient removal basins consist of separate anaerobic and anoxic tanks as described in Section 3.1.2 . This alternative differs from the oxidation ditch configuration in that it has dedicated anoxic tanks in addition to the separate anaerobic tank. The anaerobic and anoxic basins are equipped with mixers, which could be mechanical/submerged propellers or air-driven eductor mixers. Air mixers are cost effective and lower maintenance mixers that are easily implemented when blowers/air are already required for other equipment (the diffusers in this case). The process basins have an estimated footprint of 100 x 150-feet, with the anaerobic, anoxic, and aerobic basins taking up about 10%, 20%, and 70% of that footprint, respectively. The basin would include three separate trains; a train would consist of an individual anaerobic tank, anoxic tank, and aeration tank in series. The configuration would allow for one of the three trains to be offline if necessary, providing some redundancy to facilitate regular maintenance and inspections.

Internal recycle (IR) pumps are needed to pump aeration basin effluent back to the anoxic basins, with typical operating flow rates of 3-4 Q (i.e. up to 12 MGD). RAS from the secondary clarifiers is pumped back to the anaerobic basin. Three 150-HP blowers would be installed (2 duty/1standby) to supply ~3,800 scfm air to the process basins and mixers. The blowers would be housed in an adjacent building with a required building footprint of 25 x 15 feet. The blower building could be combined with other process building space such as tertiary filtration and/or disinfection equipment. A cost estimate for the concrete process basins, equipment, blowers, blower building, and associated elements is provided in Table 3-11.

Table 3-11: Cost estimate for fine bubble diffuser secondary process.

Process Basins with Fine Bubble Diffusers	
Item	**Cost**
Concrete Structure	$ 2,780,000.00
Diffuser Equipment	$ 300,000.00
Blowers	$ 300,000.00
Mixing Equipment	$ 180,000.00
Recirculation Pumps	$ 80,000.00
Blower Building	$ 86,250.00
Mechanical/Piping & Installation	$ 300,000.00
Site/Civil Work	$ 150,000.00
Electrical, Controls & Instrumentation (20%)	$ 835,250.00
Subtotal	**$ 5,011,500.00**
Contingency (25%)	$ 1,252,875.00
Engineering & Design (8%)	$ 400,920.00
Construction Management (7%)	$ 350,805.00
Legal & Administrative (3%)	$ 150,345.00
TOTAL	**$ 7,166,445.00**

As with the oxidation ditches, effluent from the diffuser basins flows through secondary clarifiers to collect sludge to be returned to the secondary process as RAS and clarify water prior to tertiary filtration and disinfection. The required clarifiers are identical to the oxidation ditch alternative, namely two (2) 90-foot diameter clarifier tanks. The cost estimate for the clarifiers is $4,703,270 as summarized in Table 3-5.

Other major elements including tertiary filtration, UV disinfection, and solids dewatering are essentially identical to those discussed and recommended for the oxidation ditch alternative. Cost estimates for each are detailed in the previous section. Table 3-12 is a summary of the total capital cost estimate for this alternative.

Table 3-12: Total capital cost estimate for fine bubble diffuser alternative.

CapEx Cost Summary	
Fine Bubble Diffusers	
Item	**Cost**
Influent Pump Station Expansion	$ 1,810,380.00
Headworks	$ 4,594,590.00
Aeration Basin Process	$ 7,166,445.00
Secondary Clarifiers	$ 4,703,270.00
Tertiary Filtration	$ 2,122,692.00
Disinfection (UV)	$ 2,042,040.00
Sludge Dewatering	$ 2,788,500.00
Dredge Old Lagoons	$ 500,000.00
TOTAL	**$ 25,727,917.00**

Operation and maintenance costs associated with this alternative include power requirements for drive motors, replacement of major wear components, and some chemical/polymer use for sludge dewatering. Power costs are estimated assuming an average cost of $0.12 per kilowatt hour. Energy demand is calculated by multiplying the average power draw of each drive motor by its anticipated run time. As with other alternatives, power is required for operating headworks equipment, though this cost is small relative to aeration and disinfection. Large power demand is mainly associated with the blowers serving the diffusers. It should be noted however that these blowers operate continuously, and rarely completely shut down. This would reduce the cost of high current draw during startup as has been noted with blowers serving the lagoons.

Internal recycle and RAS pumps have some power draw as well. Secondary clarifier drive motors are small (1 to 2 HP typically) and therefore have small operating costs. Tertiary filtration power demand is also small as drive motors are not large and backwash pumps are likewise relatively small and only operate periodically. UV disinfection has a high power demand which depends on the flow rate and the UVT of influent water. Lower UVT requires more power to disinfect an equivalent flow to the same level. Solids dewatering power demand is relatively small; WAS pumps (if required) are small (< 10 HP normally) as are the drive motors for polymer pumps, polymer mixing, and the dewatering mechanism itself (0.5 – 2 HP). Solids conveyors also have smaller drive motors (1-2 HP).

Replacement of major wear components and additional operator time/effort to deal with replacement are the other major considerations for O&M costs. For the headworks, screens usually require occasionally replacement of brushes, rollers, chains, sprockets, lamella, and other components every 3-5 years depending on use. Washpactors and grit classifiers can require occasional replacement of liners or moderate rebuilds over their lifetime.

The diffusers will require gradual replacement over their service, with the assumption that every diffuser will be replaced at least once in a 20-year period. Secondary clarifiers do not typically require major rebuilds or repairs as long as they are property maintained, tested, and regularly inspected to prevent major wear. Disc filters require occasionally replacement of disc/filter media over their service life. UV disinfection has regular wear items such as lamps, quartz sleeves, and ballasts. UV lamps typically have an average service life of 12,000 hours. Finally, screw press units can require occasionally brush replacement. Polymer is another significant annual expense that must be accounted for. Table 3-13 provides a breakdown of the O&M cost estimates for this alternative. A 20-year NPV comparison is discussed at the end of this chapter.

Table 3-13: Summary O&M estimate for fine bubble diffuser alternative.

Fine Bubble Diffuser Aeration						
ESTIMATED OPERATION, MAINTENANCE, AND REPLACEMENT COSTS						
Description	Qty (Active)	Power per unit, hp	Power per unit, kW	Operation Time, hrs per day	Total Cost/day	Total Cost/Year
HEADWORKS						
Influent Screen	2	2	1.5	6	$ 2	$ 800
Grit Trap Mechanism	1	1	0.7	24	$ 2	$ 800
Grit Pump	1	10	7.5	6	$ 5	$ 2,000
Classifier	1	1.5	1.1	4	$ 1	$ 200
Major Wear/Maintenance Parts						
Screen Brush, Bearings, Etc.						$ 2,502
Grit Equipment						$ 1,000
Labor						
Labor						$ 8,448
SECONDARY TREATMENT						
Anaerobic Basin Mixers (*Air)	3	0	0.0	24	$ -	$ -
Anoxic Basin Mixers (*Air)	6	0	0.0	24	$ -	$ -
Blowers	2	150	111.9	24	$ 645	$ 235,300
Internal Recycle Pumps	2	10	7.5	24	$ 43	$ 15,700
RAS Pumps	2	10	7.5	24	$ 43	$ 15,700
Secondary Clarifier Mechanisms	2	1	0.7	24	$ 4	$ 1,600
Major Wear/Maintenance Parts						
Blower Replacement Parts						$ 5,500
Diffuser Replacement						$ 12,500
Labor						
Labor						$ 5,368
TERTIARY FILTRATION						
Filter Drive & Backwash Pumps	Annual Power Consumption Estimate					$ 3,288
Major Wear/Maintenance Parts						
Filter Cassettes						$ 4,500
Labor						
Labor						$ 132
DISINFECTION						
UV Disinfection Modules	3		16	24	$ 138	$ 50,500
Major Wear/Maintenance Parts						
UV Lamps						$ 12,000
UV Ballasts						$ 455
Labor						
Labor						$ 2,376
SOLIDS HANDLING						
WAS Pumps	2	15	11.2	8	$ 21	$ 7,800
Screw Press Units	1	5	3.7	8	$ 4	$ 1,300
Polymer Pumps	1	0.5	0.4	8	$ 0	$ 100
Solids Conveyor	2	5	3.7	8	$ 7	$ 2,600
Major Wear/Maintenance Parts						
Brush Replacement						$ 1,250
Chemical/Labor						
Polymer						$ 22,500
Labor						$ 1,173
					Total	$ 417,392

Fine bubbler aeration systems are also a well-established, reliable technology. They have more components to maintain relative to an oxidation ditch, but unless the diffuser membrane is torn or missing, most regular maintenance is associated with the blowers. If eductor (air-driven) mixers are used, little to no maintenance is required in the anaerobic and anoxic basins. The system can be installed as multiple parallel trains, with flow split between active trains. This allows for better redundancy and facilitates draining a basin for regular inspection, maintenance, and repair. Fine bubble diffusion is more energy efficient than other options. The basins can also be tailored and scaled to meet very specific flow and loading requirements, meaning accommodating expansion is more straight forward and easier to implement.

Installations do require auxiliary equipment and building space outside of the process basin footprint, primarily for blowers. While there are no submerged components that require regular maintenance, diffused air patterns must be regularly observed to watch for tears or air leaks. Entire trains must be isolated and drained regularly to inspect diffusers and airlines, and any repairs require the tank to be bypassed and empty.

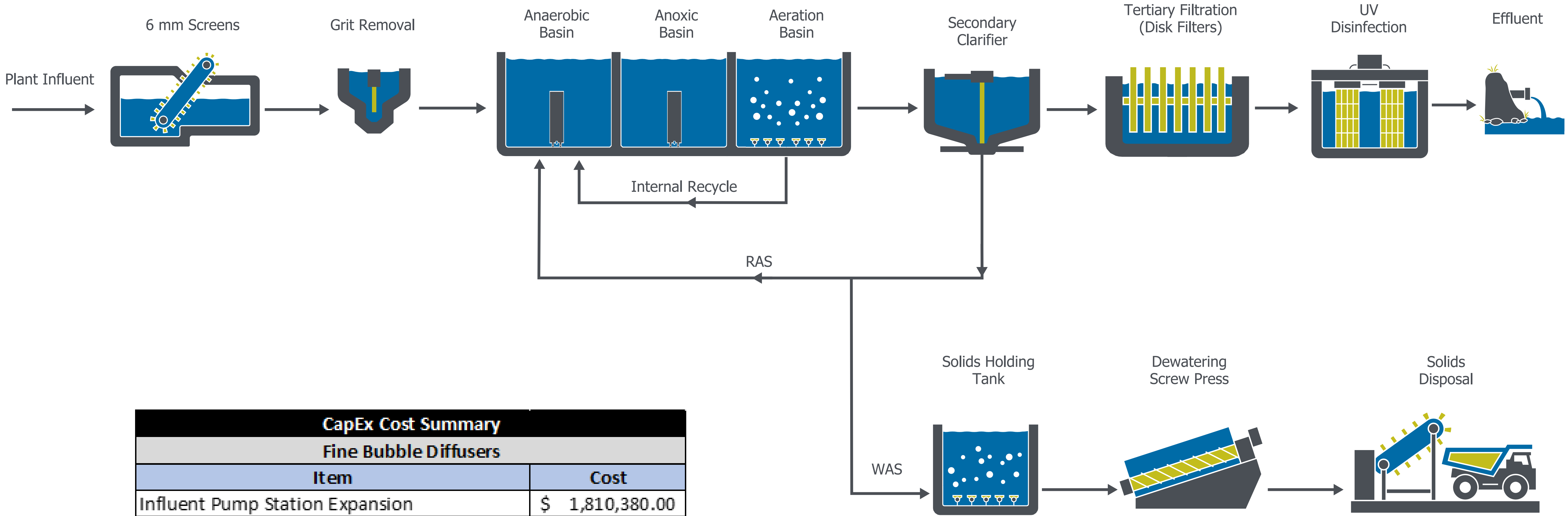
Pros:

- Simple operation with decades of operating experience at multiple installations nationwide.
- No submerged mechanical components or motors/drives in the process basin area.
- Air driven mixing can be used in anaerobic and anoxic tanks.
- More energy efficient than other activated sludge processes.
- Sizing and footprint are easily tailored to meet specific flow and loading needs, making redundancy, expansion, and installation of additional trains easier to implement.
- Generally, overall equipment, installation, and operating costs tend to be lower than other alternatives.

Cons:

- Footprint required for auxiliary equipment including blowers and internal recycle pumps.
- Diffuser inspection and replacement requires an entire train to be offline and drained.

A process flow diagram is provided in Figure 3-3 for reference.



CapEx Cost Summary	
Fine Bubble Diffusers	
Item	**Cost**
Influent Pump Station Expansion	$ 1,810,380.00
Headworks	$ 4,594,590.00
Aeration Basin Process	$ 7,166,445.00
Secondary Clarifiers	$ 4,703,270.00
Tertiary Filtration	$ 2,122,692.00
Disinfection (UV)	$ 2,042,040.00
Sludge Dewatering	$ 2,788,500.00
Dredge Old Lagoons	$ 500,000.00
TOTAL	**$ 25,727,917.00**

Figure 3-3: Fine bubble aeration process flow diagram.

3.5 Alternative 3 – Membrane Bioreactor (MBR)

The MBR alternative includes a new headworks building, nutrient removal basins (anaerobic and anoxic), aeration (fine bubble diffuser) basins, membrane tanks, internal recycle pumps, diffuser blowers, membrane scour air blowers, permeate pumps, membrane backwash/chemical cleaning equipment, UV disinfection, and solids handling equipment. Many of these facilities are similar to those described above for the oxidation ditch and fine-bubble diffuser alternatives, however the footprints, costs, and operation vary slightly. For example, MBRs require finer screening (2 mm) than other processes. Likewise, the tanks operate at higher mixed liquor concentration (8,000 – 10,000 mg/L) and require different strategies for recycling mixed liquor to accommodate both anaerobic and anoxic basin operation.

The headworks building would need very fine screening (typically 2 mm sized), which significantly increases the size of screening equipment and therefore require a larger building footprint. Grit removal technology is comparable to other options; a preliminary cost estimate for an MBR headworks facility is summarized in Table 3-14.

Effluent from the headworks enters MBR treatment trains. MBR process basins are operated at higher mixed liquor concentrations than traditional process basins (8,000 – 10,000 mg/l). Each train would consist of four distinct treatment zones or basins. The first basin operates in anaerobic conditions, mixing incoming raw wastewater with recycle from the anoxic basins. The second basin operates in anoxic conditions to provide denitrification for total nitrogen removal; a portion of the flow from the anoxic zone is recycled back to the anaerobic zone to supply PAOs to the anaerobic basin. Details of these processes are discussed in Section 3.1.2 The anaerobic and anoxic basins can be mixed with a submersible propeller mixer or with air using an eductor mixer.

Table 3-14: Cost estimate for MBR headworks building.

Headworks Building - 2mm Screens (MBR)	
Item	**Cost**
Influent Screens Equipment	$ 685,000.00
Grit Removal Equipment	$ 637,500.00
Odor Control	$ 125,000.00
Mechanical/Piping & Installation	$ 330,000.00
HVAC	$ 140,000.00
Headworks Building	$ 690,000.00
Channel/Grit Removal Concrete Work	$ 245,000.00
Yard Piping	$ 150,000.00
Site/Civil Work	$ 145,000.00
Electrical, Controls & Instrumentation (20%)	$ 629,500.00
Subtotal	**$ 3,777,000.00**
Contingency (25%)	$ 944,250.00
Engineering & Design (8%)	$ 302,160.00
Construction Management (7%)	$ 264,390.00
Legal & Administrative (3%)	$ 113,310.00
TOTAL	**$ 5,401,110.00**

Upon existing the anoxic zone, flow enters the aeration basin (3rd zone). This zone is aerated by blowers and fine bubble diffusers installed on the floor of the basin. This basin is very similar to the fine-bubble aeration equipment discussed in the previous alternative, through the sizing and operation can vary due to higher mixed liquor content. This zone includes internal recycle pumps that return a portion of the flow to the anoxic zone. The fourth zone houses the actual membrane cassettes and is usually equipped with diffusers installed directly beneath the membranes to provide scour air. Separate blowers provide sequential scour air and are usually included with the blower MBR equipment package. A cost estimate for the process basins, equipment, and associated building for this alternative is provided in Table 3-15. Note that the MBR tanks blower equipment, permeate pumps, and chemical cleaning equipment would be housed inside a building. The nutrient removal and aeration tanks are normally not enclosed. This cost estimate assumes that the MBR tanks are the only basins installed inside of the building.

Table 3-15: Cost estimate for MBR secondary process basins.

MBR with Fine Bubble Diffusers	
Item	**Cost**
MBR Concrete Basins	$ 475,000.00
Aeration & BNR Concrete Basins	$ 2,500,000.00
BNR Basin Mixing Equipment	$ 180,000.00
Membrane Equipment Package	$ 3,600,000.00
Membrane Blowers	$ 100,000.00
Fine Bubble Diffuser Package	$ 300,000.00
Fine Bubble Blowers	$ 300,000.00
Recirculation Pumps	$ 80,000.00
Membrane/Equipment Building	$ 1,335,000.00
Mechanical Installation	$ 680,000.00
Site/Civil Work	$ 250,000.00
Electrical, Controls & Instrumentation (20%)	$ 1,960,000.00
Subtotal	**$11,760,000.00**
Contingency (25%)	$ 2,940,000.00
Engineering & Design (8%)	$ 940,800.00
Construction Management (7%)	$ 823,200.00
Legal & Administrative (3%)	$ 352,800.00
TOTAL	**$16,816,800.00**

A membrane bioreactor is a conventional activated sludge process system with membranes replacing secondary clarifiers tertiary filtration. Membranes consist of sheets or tubes with small openings that prevent solids from passing through. Wastewater is pulled through the membranes by permeate pumps, leaving solids and sludge behind. Membrane effluent, known as permeate, already meets Type I reuse requirements for BOD, TSS, and turbidity. The MBR process does not rely on gravity sedimentation or additional tertiary filtration to separate clear water from solids. Operating mixed liquor concentrations in the biological process basins is much higher than traditional activated sludge processes, resulting in smaller required basin volumes and footprints. This, coupled with elimination of secondary clarifiers and building space for tertiary filtration, yields a much smaller overall footprint than oxidation ditches or diffuser processes. As with the fine bubble diffuser alternative, three or four MBR trains would be installed, providing redundancy, and giving operators the ability to isolate and bypass individual trains for inspection and maintenance.

The permeate produced from the membranes is high quality, and as it is pumped, UV disinfection can be conducted in closed vessels rather than open channel installations. Closed vessel UV units have a much smaller footprint than open channel equipment. The high-quality effluent has reliably high UVT, which can reduce the overall capacity and energy consumption of UV disinfection. A cost estimate using two (2) Trojan UVFlex 100 closed vessel units is provided in Table 3-16. Costs for solids handling and dewatering are essentially identical to those discussed and recommended for the oxidation ditch alternative. Cost estimate for solids handling is provided in Table 3-8 above. Table 3-17 is a summary of the total capital cost estimate for this alternative.

Table 3-16: Cost estimate for MBR closed vessel UV.

UV Disinfection - Closed Vessel (MBR)	
Item	**Cost**
UV Equipment Package	$ 975,000.00
Equipment Room	$ 185,000.00
Mechanical Installation	$ 100,000.00
Site/Civil Work	$ 40,000.00
Electrical, Controls & Instrumentation (20%)	$ 260,000.00
Subtotal	**$ 1,560,000.00**
Contingency (25%)	$ 390,000.00
Engineering & Design (8%)	$ 124,800.00
Construction Management (7%)	$ 109,200.00
Legal & Administrative (3%)	$ 46,800.00
TOTAL	**$ 2,230,800.00**

Table 3-17: Total capital cost estimate for MBR alternative.

CapEx Cost Summary	
MBR	
Item	**Cost**
Influent Pump Station Expansion	$ 1,810,380.00
Headworks	$ 5,401,110.00
MBR Process	$ 16,816,800.00
Secondary Clarification	N/A
Tertiary Filtration	N/A
Disinfection (UV)	$ 2,230,800.00
Sludge Dewatering	$ 2,788,500.00
Dredge Old Lagoons	$ 500,000.00
TOTAL	**$ 29,547,590.00**

Operation and maintenance costs associated with this alternative include power requirements for drive motors, replacement of major wear components, and some chemical/polymer use for sludge dewatering. Power costs are estimated assuming an average cost of $0.12 per kilowatt hour. Energy demand is calculated by multiplying the average power draw of each drive motor by its anticipated run time. As with other alternatives, power is required for operating headworks equipment, though this cost is small relative to aeration and disinfection. Large power demand is mainly associated with the large blowers serving the diffusers in the aeration and membrane basins as well as the membrane permeate pumps. As discussed above, that these blowers operate continuously, and rarely completely shut down.

Internal recycle pumps have some power draw as well. Flow must be suctioned through the membranes, pumped through disinfection, and on to discharge. Thus permeate pumps, typically consisting of multiple 20-30 HP pumps add significant cost to power cost as well. The chemical pump/cleaning system requires some power, but more cost is associated with cleaning chemicals (sodium hypochlorite, citric acid, etc.). Anticipated power consumption for UV disinfection is 10-15% less compared to other alternatives given the consistently high UVT inherent with MBR permeate. Solids dewatering power demand is relatively small; WAS pumps (if required) are small (< 10 HP normally) as are the drive motors for polymer pumps, polymer mixing, and the dewatering mechanism itself (0.5 – 2 HP). Solids conveyors also have smaller drive motors (1-2 HP).

Replacement of major wear components and additional operator time/effort to deal with replacement are the other major considerations for O&M costs. For the headworks, screens usually require occasionally replacement of brushes, rollers, chains, sprockets, lamella, and other components every 3-5 years depending on use. Washpactors and grit classifiers can require occasional replacement of liners or moderate rebuilds over their lifetime. Screen/washpactor maintenance costs may be slightly higher as the equipment is larger and will be removing/handling more debris. The diffusers in the aeration tank will require gradual replacement over their service, with the assumption that every diffuser will be replaced at least once in a 20-year period. The membrane cassettes themselves also wear out; intake pressure gradually increases as the small openings become more and more fouled. The membranes can also tear or occasionally become damaged. Average replacement costs/intervals over a 20-year life for membranes are considered in this O&M cost estimate.

UV disinfection has regular wear items such as lamps, quartz sleeves, and ballasts. UV lamps typically have an average service life of 12,000 hours. Finally, screw press units can require occasionally brush replacement. Polymer is another significant annual expense that must be accounted for. Table 3-18 provides a breakdown of the O&M cost estimates for this alternative. A 20-year NPV comparison is discussed at the end of this chapter.

Table 3-18: Summary O&M costs for MBR alternative.

MBR						
ESTIMATED OPERATION, MAINTENANCE, AND REPLACEMENT COSTS						
Description	Qty (Active)	Power per unit, hp	Power per unit, kW	Operation Time, hrs per day	Total Cost/day	Total Cost/Year
HEADWORKS						
Self-Contained Screen	2	3	2.2	8	$ 4	$ 1,600
Grit Trap Mechanism	1	0.5	0.4	24	$ 1	$ 400
Grit Pump	1	10	7.5	6	$ 5	$ 2,000
Classifier	1	0.5	0.4	3	$ 0.13	$ -
Major Wear/Maintenance Parts						
Screen Brush, Bearings, Etc.						$ 2,723
Grit Equipment						$ 1,000
Labor						
Labor						$ 8,917
SECONDARY TREATMENT						
Anaerobic Basin Mixers	3	0	0.0	24	$ -	$ -
Anoxic Basin Mixers	6	0	0.0	24	$ -	$ -
Aeration Basin Blowers	2	150	111.9	24	$ 645	$ 235,300
MBR Air Scour Blowers	3	90	67.1	4	$ 97	$ 35,300
Internal Recycle Pumps	2	10	7.5	24	$ 43	$ 15,700
RAS Pumps	2	10	7.5	24	$ 43	$ 15,700
Permeate Pumps	4	25	18.7	24	$ 215	$ 78,400
Major Wear/Maintenance Parts						
Blower Replacement Parts (?)						$ 7,800
Diffuser Replacement						$ 12,500
MBR Replacement						$ 65,600
Labor/Chemical						
Chemical Clean Pumps						$ 2,000
Chemical Usage						$ 7,665
Labor						$ 6,336
DISINFECTION						
UV Disinfection Modules	1	-	42.0	24	$ 121	$ 44,200
Major Wear/Maintenance Parts						
UV Lamps						$ 18,667
UV Ballasts						$ 400
Labor						
Labor						$ 1,203
SOLIDS HANDLING						
WAS Pumps	2	15	11.2	8	$ 21	$ 7,800
Screw Press Units	1	5	3.7	8	$ 4	$ 1,300
Polymer Pumps	1	0.5	0.4	8	$ 0	$ 100
Solids Conveyor	2	5	3.7	8	$ 7	$ 2,600
Major Wear/Maintenance Parts						
Brush Replacement						$ 1,250
Chemical/Labor						
Polymer						$ 22,500
Labor						$ 1,173
					Total	$ 600,134

MBRs have more components and require more day-to-day inspection and observation to operate. The technology is now well established but can be more challenging to operate with higher mixed liquor levels and smaller tanks (HRT) times. MBRs offer the most compact footprint and best effluent quality of all alternatives explored in this study. While they don't require secondary clarifiers and tertiary filtration, this alternative is the least energy efficient as membrane permeate must be pumped, the membranes themselves require additional scour air, and the chemical system uses some energy. In addition, the membrane cassettes and associated air scour system introduce additional wear and maintenance items on top of traditional diffuser basins.

If eductor (air-driven) mixers are used, little to no maintenance is required if eductor (air-driven) mixers are used in the anaerobic and anoxic basins. The system can be installed as multiple parallel trains, with flow split between active trains. This allows for better redundancy and facilitates draining a basin for regular inspection, maintenance, and repair. The basins can also be tailored and scaled to meet very specific flow and loading requirements, meaning accommodating expansion is more straight forward and easier to implement.

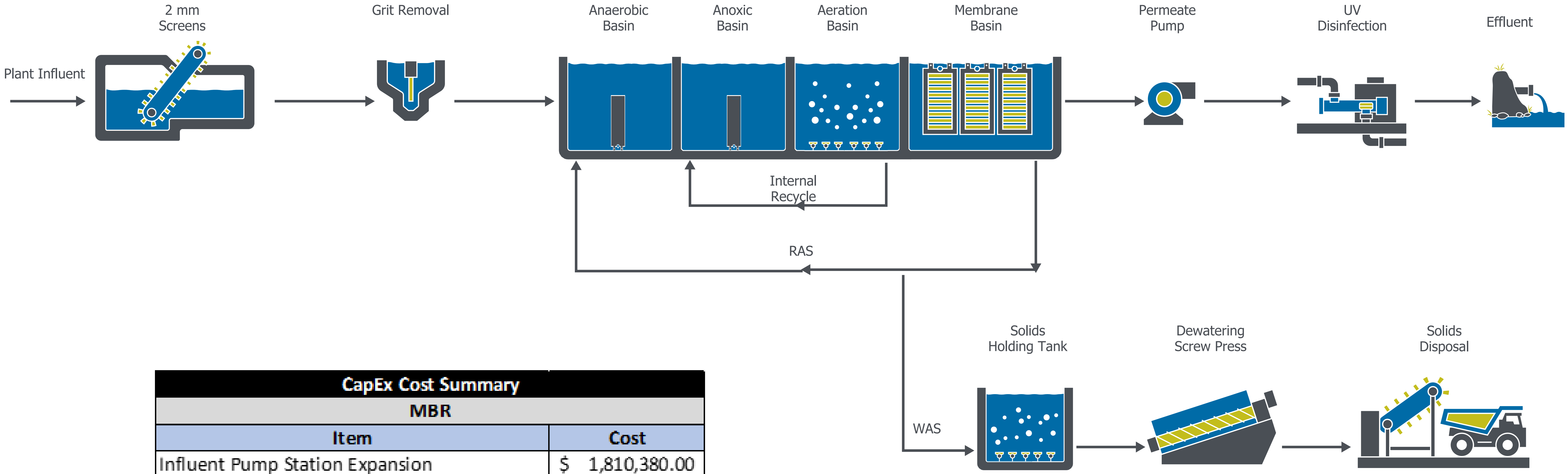
Pros*:*

- Very compact footprint.
- No secondary clarifiers or tertiary filtration needed for Type I reuse.
- High quality effluent.
- Lower energy for UV disinfection due to high quality effluent.

Cons*:*

- Larger, more expensive headworks equipment required.
- Most expensive alternative for both installation and operational costs.
- Additional equipment such as air scour blowers, permeate pumps, and chemical cleaning equipment to install, operate, and maintain.
- Requires chemical storage and handling for membrane maintenance.

A process flow diagram is provided in Figure 3-4 for reference.



CapEx Cost Summary	
MBR	
Item	**Cost**
Influent Pump Station Expansion	$ 1,810,380.00
Headworks	$ 5,401,110.00
MBR Process	$ 16,816,800.00
Secondary Clarification	N/A
Tertiary Filtration	N/A
Disinfection (UV)	$ 2,230,800.00
Sludge Dewatering	$ 2,788,500.00
Dredge Old Lagoons	$ 500,000.00
TOTAL	**$ 29,547,590.00**

Figure 3-4: MBR process flow diagram.

3.6 Alternative 4 – Parallel Lagoon and Fine Bubble Diffuser System

The final alternative reviewed in this study maintains operation of the lagoons at their practical operating limit (1 MGD) and increasing capacity with a parallel, 2 MGD activated sludge system. For this comparison, we utilized the least expensive and easiest alternative to scale at either 2 or 3 MGD (e.g. fine bubble diffusers), but a parallel system could be implemented with any of the first 3 alternatives discussed above.

This parallel system would include a new headworks building (screens, grit removal) that would treat all influent for the lagoons and aeration basin processes. The recommended headworks is the same as described above for the oxidation ditch and fine bubble diffuser alternatives with an estimated cost of $4,594,590 (Table 3-3). Effluent from the headworks would enter a splitter box to split flow between the lagoons and aeration basins. The new aeration process would include anaerobic and anoxic tanks as described in Alternative 2 above, but only 2 of 3 trains would be installed. Some appurtenances, such as piping and the blower building, would still be sized to accommodate a future 3 MGD plant, but not all blower equipment or concrete basins would be installed initially. These basins would require internal recycle pumping (up to 8 MGD). An adjusted cost estimate for a 2 MGD fine bubble diffuser process is provided in Table 3-19. Note that this represents roughly 70% of the estimated 3 MGD cost.

Secondary clarifiers and tertiary filtration would follow the diffuser basins. Two smaller (75-foot diameter) clarifiers would be installed. A future 3rd clarifier could be built if the process is expanded to 3 MGD. Less tertiary filtration capacity would also be installed, but the building and infrastructure would be designed to accommodate expansion to 3 MGD. Adjusted cost estimates for 2 MGD secondary clarification and tertiary filtration are provided in Table 3-20 and Table 3-21.

Table 3-19: Cost estimate for 2 MGD fine bubble diffuser process.

Process Basins with 2 MGD Fine Bubble Diffusers	
Item	**Cost**
Concrete Structure	$ 1,950,000.00
Diffuser Equipment	$ 200,000.00
Blowers	$ 200,000.00
Mixing Equipment	$ 120,000.00
Recirculation Pumps	$ 55,000.00
Blower Building	$ 86,250.00
Mechanical/Piping & Installation	$ 200,000.00
Site/Civil Work	$ 100,000.00
Electrical, Controls & Instrumentation (20%)	$ 582,250.00
Subtotal	**$ 3,493,500.00**
Contingency (25%)	$ 873,375.00
Engineering & Design (8%)	$ 279,480.00
Construction Management (7%)	$ 244,545.00
Legal & Administrative (3%)	$ 104,805.00
TOTAL	**$ 4,995,705.00**

Table 3-20: Cost estimate for 75-foot diameter secondary clarifiers.

Secondary Clarifiers - 2 MGD Aeration	
Item	**Cost**
(2) Clarifier Concrete Structures	$ 1,800,000.00
(2) Clarifier Mechanisms	$ 700,000.00
RAS/WAS Pumps	$ 45,000.00
Mechanical Installation	$ 50,000.00
Site/Civil Work	$ 125,000.00
Electrical, Controls & Instrumentation (10%)	$ 272,000.00
Subtotal	**$ 2,992,000.00**
Contingency (25%)	$ 748,000.00
Engineering & Design (8%)	$ 239,360.00
Construction Management (7%)	$ 209,440.00
Legal & Administrative (3%)	$ 89,760.00
TOTAL	**$ 4,278,560.00**

Table 3-21: Cost estimate for 2 MGD capacity tertiary filtration.

Tertiary Disc Filtration - 2 MGD	
Item	**Cost**
Disc Filter Equipment Package	$ 575,000.00
Equipment Room	$ 250,000.00
Mechanical Installation	$ 70,000.00
Site/Civil Work	$ 40,000.00
Electrical, Controls & Instrumentation (20%)	$ 187,000.00
Subtotal	**$ 1,122,000.00**
Contingency (25%)	$ 280,500.00
Engineering & Design (8%)	$ 89,760.00
Construction Management (7%)	$ 78,540.00
Legal & Administrative (3%)	$ 33,660.00
TOTAL	**$ 1,604,460.00**

Finally, the UV disinfection system would be an open channel system, similar to what was presented in Alternative 2 at a reduced scale. Table 3-22 summarizes the 2 MGD UV disinfection cost estimate .

Table 3-22: Cost estimate for 2 MGD open channel UV system.

UV Disinfection -2 MGD	
Item	**Cost**
UV Equipment Package	$ 600,000.00
Equipment Room	$220,000
Mechanical Installation	$ 75,000.00
Site/Civil Work	$ 55,000.00
Electrical, Controls & Instrumentation (20%)	$ 190,000.00
Subtotal	**$ 1,140,000.00**
Contingency (25%)	$ 285,000.00
Engineering & Design (8%)	$ 91,200.00
Construction Management (7%)	$ 79,800.00
Legal & Administrative (3%)	$ 34,200.00
TOTAL	**$ 1,630,200.00**

In addition to the capital costs summarized herein for a 2 MGD aeration process, the upgrades to the lagoons listed in Section 3.2 (and Table 3-1) would be required to extend the service life of the lagoons and ensure that they can fully handle 1 MGD. In review, these upgrades and repairs include: chemical addition for enhanced P removal; replacing worn/damaged diffusers; replacing damaged/leaking 24-inch air lines; replacing decant valves; replacing biocurtains in the primary lagoon; installing power and control for floating aerators in the 3rd lagoon; upgrading controls for the lagoon UV disinfection system; and dredging sludge from the lagoons. Table 3-23 is a summary of all capital costs for this parallel system alternative.

Table 3-23: Total capital cost estimate for parallel processes alternative.

CapEx Cost Summary	
2.0 MGD Fine Bubble	
Item	**Cost**
Influent Pump Station Expansion	$ 1,810,380.00
Headworks	$ 4,594,590.00
Aeration Basin Process	$ 4,995,705.00
Secondary Clarifiers	$ 4,278,560.00
Tertiary Filtration	$ 1,604,460.00
Disinfection (UV)	$ 1,630,200.00
Sludge Dewatering	$ 1,887,600.00
Lagoon Rehab & Upgrades*	$ 5,436,860.00
TOTAL	**$ 26,238,355.00**

* Refer to Table 3-1 for details on rehabilitation of existing improvements.

Operation and maintenance costs associated with this alternative include power requirements for drive motors, replacement of major wear components, and some chemical/polymer use for sludge dewatering. Power costs are estimated assuming an average cost of $0.12 per kilowatt hour. Energy demand is calculated by multiplying the average power draw of each drive motor by its anticipated run time. As with other alternatives, power is required for operating headworks equipment, though this cost is small relative to aeration and disinfection. Large power demand is mainly associated with the large blowers serving the fine bubble and lagoon diffusers. The floating aerators also add significant power consumption. Note that the lagoon blowers tend to cycle on and off frequently, resulting in loading/usage charges on top of normal energy rates. Power cost estimates used in this study for the lagoon system are extrapolated based on 2021-2022 power utility bills for the WWTP site provided by the City.

Other power consuming components of the 2 MGD aeration process include internal recycle pumps, secondary clarifier drive motors (and RAS pumps), and the tertiary filtration drive motors and backwash pumps. Internal recycle and RAS pumps have the largest power draw of these elements (multiple 10-15 HP pumps). Secondary clarifier drive motors are small (1 to 2 HP typically) and therefore have small operating costs. Tertiary filtration power demand is also small as drive motors are not large and backwash pumps are likewise relatively small and only operate periodically. UV disinfection has a high power demand which depends on the flow rate and the UVT of influent water. Lower UVT requires more power to disinfect an equivalent flow to the same level. Solids dewatering power demand is relatively small; WAS pumps (if required) are small (< 10 HP normally) as are the drive motors for polymer pumps, polymer mixing, and the dewatering mechanism itself (0.5 – 2 HP). Solids conveyors also have smaller drive motors (1-2 HP).

Replacement of major wear components and additional operator time/effort to deal with replacement are the other major considerations for O&M costs. For the headworks, screens usually require occasionally replacement of brushes, rollers, chains, sprockets, lamella, and other components every 3-5 years depending on use. Washpactors and grit classifiers can require occasional replacement of liners or moderate rebuilds over their lifetime. The aeration basin and lagoon diffusers will require gradual replacement over their service, with the assumption that every diffuser will be replaced at least once in a 20-year period. In addition, the lagoons would require replacement of the biocurtains over a 20-year service life.

Secondary clarifiers do not typically require major rebuilds or repairs as long as they are property maintained, tested, and regularly inspected to prevent major wear. Disc filters require occasionally replacement of disc/filter media over their service life. UV disinfection has regular wear items such as lamps, quartz sleeves, and ballasts. UV lamps typically have an average service life of 12,000 hours. Finally, screw press units can require occasionally brush replacement. Polymer is another significant annual expense that must be accounted for.

Chemical addition for P removal is an additional expense with this alternative. Preliminary jar testing indicate that achieve ~0.8 mg/L in lagoon effluent at 1 MGD would require $60,00 to $150,000+ per year in chemical. The large variability is due to unknown factors of chemical injection including competing reactions and mixing inefficiencies. Consistency of influent wastewater can vary, and certain constituents and contaminants can consume P flocculating chemical. Chemical injection later in the process could reduce this impact, but effective and complete chemical mixing and entrainment is difficult to achieve in a large lagoon volume. The most effective location to inject chemical would be in the headworks where a small flash mixing assembly could be installed. Another location discussed with operators is the transfer/decanter boxes. There are four transfer chambers with relatively small volumes. However, each box would need to be equipped with chemical injection piping and diffusers as well as mixer. Regardless of how chemical addition is implemented, annual costs for P removal are a significant factor in our cost estimate. Continued use of the lagoons, especially with chemical P removal, will require dredging every 10 years to maintain depth and efficient operation. This is another major O&M cost associated with this alternative. Table 3-24 provides a summary of the O&M cost estimates for this alternative. A 20-year NPV comparison is discussed at the end of this chapter.

Table 3-24: Summary O&M costs for parallel processes alternative.

Parallel Lagoon & Aeration Basins						
ESTIMATED OPERATION, MAINTENANCE, AND REPLACEMENT COSTS						
Description	**Qty**	**Power per unit, hp**	**Power per unit, kW**	**Operation Time, hrs per day**	**Total Cost/day**	**Total Cost/Year**
HEADWORKS						
Influent Screen	2	2	1.5	6	$ 2	$ 800
Grit Trap Mechanism	1	1	0.7	24	$ 2	$ 800
Grit Pump	1	10	7.5	6	$ 5	$ 2,000
Classifier	1	1.5	1.1	4	$ 1	$ 200
Major Wear/Maintenance Parts						
Screen Brush, Bearings, Etc.						$ 2,502
Grit Equipment						$ 1,000
Labor						
Labor						$ 8,448
SECONDARY TREATMENT						
2.0 MGD Fine Bubbler Aeration System						
Anaerobic Basin Mixers	3		0.0	16	$ -	$ -
Anoxic Basin Mixers	6		0.0	16	$ -	$ -
Blowers	2	150	111.9	16	$ 430	$ 156,800
Internal Recycle Pumps	2	10	7.5	24	$ 29	$ 10,500
RAS Pumps	2	10	7.5	24	$ 29	$ 10,500
Secondary Clarifier Mechanisms	1	1	0.7	24	$ 2	$ 800
Existing Lagoons @ 1.0 MGD Capacity						
Lagoon Aeration Power						$ 149,416
Lagoon Mixers	4	5	3.7	24	$ 43	$ 15,700
Major Wear/Maintenance Parts						
Blower Replacement Parts						$ 3,667
Diffuser Replacement						$ 8,333
Lagoon Diffuser Replacement						$ 10,000
Baffle Replacement						$ 7,500
Chemical						
Alum for P Removal (Lagoons)						$ 60,000
Labor						
Fine Bubble Diffuser Labor						$ 3,579
Lagoon Diffuser Labor						$ 7,157
Additionanl Employee for Dual System						$ 80,000
TERTIARY FILTRATION						
Filter Drive & Backwash Pumps	Annual Power Consumption Estimate					$ 2,192
Major Wear/Maintenance Parts						
Filter Cassettes						$ 3,000
Labor						
Labor						$ 132
DISINFECTION						
UV Disinfection Modules						$ 33,667
Major Wear/Maintenance Parts						
UV Lamps						$ 8,000
UV Ballasts						$ 303
Labor						
Labor						$ 1,584
SOLIDS HANDLING						
WAS Pumps	2	15	11.2	8	$ 21	$ 5,200
Screw Press Units	1	5	3.7	8	$ 4	$ 867
Polymer Pumps	1	0.5	0.4	8	$ 0	$ 67
Solids Conveyor	2	5	3.7	8	$ 7	$ 1,733
Major Wear/Maintenance Parts						
Brush Replacement						$ 833
Lagoon Sludge Dredging						$ 300,000
Chemical/Labor						
Polymer						$ 15,000
Labor						$ 782
					Total	$ 913,062

While it is a worthwhile exercise to explore utilizing and maximizing the life of existing improvements, this study indicates that attempting to operate a parallel process with the lagoons does not offer cost savings or benefit in terms of 20-year NPV. Operating two separate plants would be difficult for staff, and likely require more personnel than a single process. The lagoons are less energy efficient than other options. The need to install and purchase chemical for P removal from the lagoons makes this option even less cost effective. Other cons include continued high-cost maintenance items such as frequent sludge dredging, and repair of aging pipelines, diffusers, and blowers. Lagoon effluent is difficult to filter sufficiently to meet Type I effluent, so any flow sent to the lagoons would be discharged instead of reused.

Contrary to convention, the practical effluent P limit for the lagoons is more stringent than for a mechanical plant. Conversation with the State indicates that changing the lagoon permit loading is very unlikely. It is more difficult and costly to remove phosphorus from the lagoon process than biologically in a new process.

Proceeding with the lagoons and a parallel system could decrease initial capital costs, especially if some lagoon maintenance items are deferred. However, this relief would be very temporary as most of the recommended maintenance and upgrades for the lagoon process would need to occur over the next few years (e.g. dredging of the ponds and installation of chemical addition equipment). In summary, the apparent capital and 20-year NPV of this alternative, coupled with the complexity of operating two systems render this alternative the least practical of the four.

Pros:

- Potential for less capital costs initially, though they are higher long-term.
- Allows for extended expansion and more gradual phasing of new process.

Cons:

- Difficult and more costly to operate 2 separate systems.
- Costs for dredging the lagoons and chemical P removal are relatively high.
- Lower quality effluent from the ponds not practical for reuse water applications.

- One of the more expensive alternatives long-term compared with a single, more energy efficient process.
- Many of the buildings and pipelines for the 2 MGD process would need to be sized to accommodate a 3 MGD plant to allow for eventual replacement of lagoons.
- Requires chemical storage and handling for phosphorus removal.

3.7 Comparison and Summary of Alternatives

All alternatives presented in this study would increase WWTP capacity to treat 3 MGD (and associated constituent loading) to meet permit requirements. Alternatives 1 thru 3 could treat all 3 MGD to Type I reuse standards. Alternative 4 would treat 2 MGD to Type I quality, while the remaining 1 MGD treated in the lagoons would discharge to the ditches. The benefits, limitations, and potential issues associated with each alternative were reviewed in detail with City and WWTP operation staff. Overall capital cost is a major consideration, along with anticipated O&M costs. In addition, qualities such as operability, reliability, effluent quality, and operator preferences should be considered. Other factors such as footprint are less critical given the space available at the size but merit some consideration with regards to site layout and construction costs.

Comparing initial capital costs, the fine bubble diffuser alternative is estimated to be the least expensive, followed by a parallel system, the oxidation ditch option, with MBR as the most expensive (Table 3-25). These cost estimates are preliminary, include 25% contingency, and are based on preliminary equipment cost and scope estimates solicited from equipment suppliers. The capital cost difference between oxidation ditches, fine bubble diffusers, and even the parallel system are close enough that the decision should not be based solely on these cost estimates.

Annual O&M costs for each alternative were estimated from anticipated power usage (based on $0.12 per kilowatt hour), and replacement of major wear/maintenance items averaged over a 20-year service life. For example, fine bubble diffusers, on average, are expected to need one complete replacement over a 20-year service life. Thus, the expense to purchase and replace all of the diffusers is averaged over 20 years. Another example, brushes for influent screens are a wear item that require replacement every 5 years. Thus, replacement of these brushes every 5 years over a 20-year service life is again averaged annually over the 20-year period. Other O&M considerations included in these estimates are: additional operator manhours needed to complete extra maintenance and repair work; chemical consumption (e.g. polymer or for phosphorus removal in the lagoons); and the cost of wear/replacement parts. Annual O&M costs (based on 2022 prices) ranged from $417,000 for fine bubble diffusers, to over $900,000 for a parallel lagoon/diffuser installation.

The capital cost for each alternative is combined with a 20-year net present value calculation of the estimated O&M costs to return a total, 20-year NPV of the entire project. The NPV calculation assumes an average inflation rate of 3%, and a discount rate of 6%. The total NPV of the alternatives is summarized in Table 3-26

Table 3-25: Capital cost comparison.

	CapEx Cost Summary			
	All New 3 MGD Process			2 MGD/1MGD
	Ox Ditch	FB Diffusers	MBR	Parallel System
Item	**Cost**	**Cost**	**Cost**	**Cost**
Influent Pump Station	$ 1,810,380.00	$ 1,810,380.00	$ 1,810,380.00	$ 1,810,380.00
Headworks	$ 4,594,590.00	$ 4,594,590.00	$ 5,401,110.00	$ 4,594,590.00
Oxidation Ditch Process	$ 9,154,860.00	$ 7,166,445.00	$ 16,816,800.00	$ 4,995,705.00
Secondary Clarifiers	$ 4,703,270.00	$ 4,703,270.00	N/A	$ 4,278,560.00
Tertiary Filtration	$ 2,122,692.00	$ 2,122,692.00	N/A	$ 1,604,460.00
Disinfection (UV)	$ 2,042,040.00	$ 2,042,040.00	$ 2,230,800.00	$ 1,630,200.00
Sludge Dewatering	$ 2,788,500.00	$ 2,788,500.00	$ 2,788,500.00	$ 1,887,600.00
Dredge Old Lagoons	$ 500,000.00	$ 500,000.00	$ 500,000.00	$ 5,436,860.00
TOTAL	**$ 27,716,332.00**	**$ 25,727,917.00**	**$ 29,547,590.00**	**$ 26,238,355.00**

Table 3-26: Total 20-year NPV comparison.

Total 20-Year NPV Comparison				
Process	**Cap Ex**	**2022 Op Ex**	**20-Year NPV Op Ex**	**Total 20-Year NPV**
Fine Bubble Diffusers (3 MGD)	$ 25,727,917	$ 417,392	$ 6,442,544	**$ 32,170,461**
Oxidation Ditches (3 MGD)	$ 27,716,332	$ 468,670	$ 7,234,032	**$ 34,950,364**
MBR (3 MGD)	$ 29,547,590	$ 600,134	$ 9,196,338	**$ 38,743,928**
Lagoons (1 MGD)* & Fine Bubble Diffusers(2 MGD)	$ 26,238,355	$ 913,062	$ 14,093,314	**$ 40,331,669**

The overall most cost-effective alternative appears to be the fine bubbler diffusers. The oxidation ditch alternative is relatively close, and the cost difference between the two options is small enough that other factors should be considered. The MBR option is more expensive to build and operate. One of the biggest benefits MBR offers is a reduced footprint. While this is a nice feature, the WWTP site is sufficiently large to easily accommodate any of the alternatives discussed here, so a smaller footprint is of secondary concern. MBR does provide the highest quality effluent, but Type I reuse quality can be reached by adding tertiary filtration to either the oxidation ditch or fine bubble alternative (already included in above pricing). Thus, while the MBR alternative would be effective, the higher cost does not appear justified.

Expansion while using the lagoons in parallel does not appear to offer much benefit to the City. Short-term, some expansion costs could be deferred for a few years (up to 5-10 potentially), but much of these savings are negated by improvements, repairs, and maintenance items needed in the lagoons such as chemical addition, dredging, and biocurtain repair. Considering the added operational complexity and long-term higher costs, this alternative is the least viable.

This leaves the two most viable alternatives as oxidation ditch and fine bubble diffusers. Either would be a reasonable, cost-effective solution. Operating staff view both technologies favorably, but offered the following insights and opinions in comparing the two:

Fine Bubble Diffusers:

- Smaller footprint/basins are preferred over oxidation ditch structures.
- Capacity/sizing and expansion are easier to design and accommodate with diffusers, as additional basins can be added to accommodate any flow/loading combination.
- Operators are already familiar with operating and maintaining diffusers and blowers due to the lagoon system.
- Better oxygen transfer and energy efficiency.
- Operators have had difficulty accessing/replacing diffusers in the lagoons, but access in concrete basins will be improved as they can be easily isolated and drained.

- Diffusers and blowers could be a bit more involved in terms of inspection, operation, and overall maintenance, but the workload is acceptable to operators.
- The slightly lower HRT would make the process a bit more susceptible to process interruptions and conditions falling outside of target ranges.

Oxidation Ditches:

- Operators believe this is the simplest overall equipment to operate and maintain.
- Operators like feedback from other installations, including that it's fairly forgiving in terms of operating outside of ideal parameters.
- Operators realize there is less flexibility with scaling and expansion of this type of technology compared to diffusers.
- The newer Orbal disks look to be more robust and durable, but there aren't many installations with long-term experience.
- Energy efficiency may be less than other options.

Overall, given the potential slight cost advantage and operators preference, the fine bubble diffuser alternative is the recommended option. Final recommendations and courses of action discussed in Chapter 4 are based on this alternative.

CHAPTER 4 - CONCLUSION & RECOMMENDATIONS

Projected loading to the WWTP from the Grantsville service area is rapidly approaching the practical limit of the existing lagoon process. The lagoons already cannot adequately remove phosphorous to meet permit requirements. Even with chemically enhanced P removal, influent flow will likely exceed their capacity within the next few years. The following sections summarize the need, recommended alternative, and provide a tentative schedule for budgeting, planning, design, and construction of recommended upgrades.

4.1 Timing and Project Need

As established, the lagoons are not equipped to meet effluent P requirements and operators anticipate exceeding the total effluent P load this year. Aqua's correspondence with State DEQ staff indicates that this violation will normally trigger a 5-year window in which planning and implementation to bring the WWTP into compliance is expected. Chemical addition could be added to the lagoons to improve effluent P levels and meet permit. This could likely be installed within 6 months of completing design and has already been discussed with operators. However, given the anticipated rapid growth of the service area and future flow/loading, a larger-scale upgrade to address effluent P and increase total capacity are recommended.

As summarized in Chapter 2, it is recommended that the City install a 3 MGD capacity plant to accommodate growth through ~2042. The facility should be sized to handle 250 mg/L of BOD and TSS (6,255 #/day), as well as 55 mg/L TKN and 6 mg/L P influent. The recommended design peak hour capacity is 7.0 MGD.

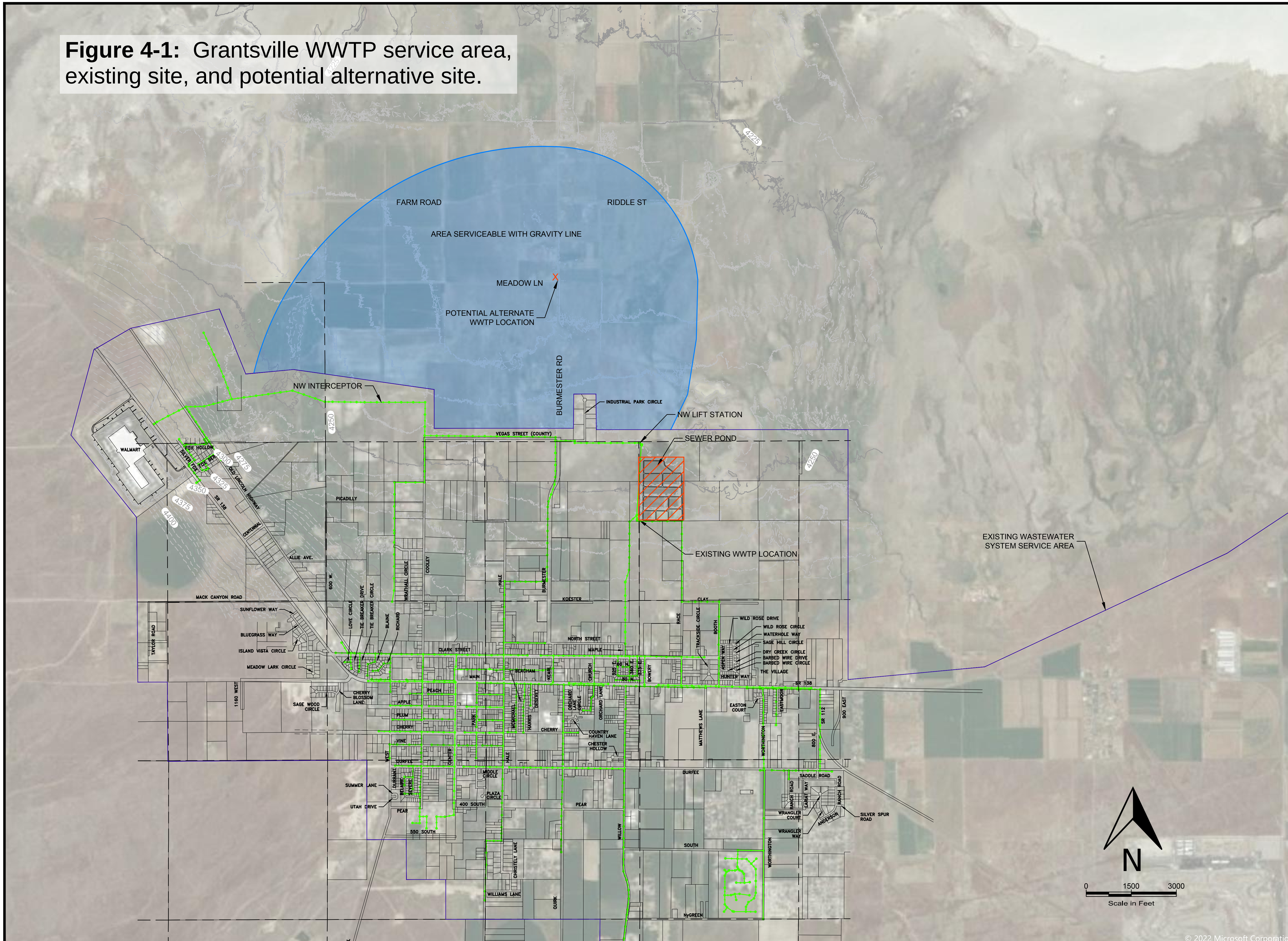
Growth projections indicate that even with chemical addition, the lagoon's 1 MGD capacity will likely be reached within 3-4 years. Furthermore, chemical addition for P removal for flows above 1 MGD becomes more cost prohibitive due to chemical demand and increased frequency of dredging/sludge removal. In our opinion, the capital and design effort would be best served investing in a new 3 MGD plant. The 5-year window for compliance leaves sufficient time as long as progress continues unabated. Following is a recommended schedule for implementation of any upgrades:

- **2022**: Finalize study and recommendations.
- **2022–2023**: Explore funding options and secure capital via city funds, bonding, grants, loans, and user rate adjustments. Funding should include a formal Impact Fee Facilities Plan (IFFP). Decision on whether or not to relocate the WWTP site should be finalized prior to commencement of detailed design work.
- **2023**: Conduct formal equipment selection process for major process equipment including screens, grit removal, blowers, diffusers, mixers, clarifier mechanisms, UV disinfection equipment, and sludge dewatering/polymer systems.
- **2023-2024**: Complete detailed design of project.
- **2024**: Conduct bidding process to select installation contractor.
- **2025-2026**: Complete construction, startup, and commissioning of new facility.
- **2026-2027**: Decommission lagoon treatment process; dry and remove sludge form ponds; convert to reuse water storage if desired.

4.2 WWTP Site Location

The City has discussed relocating the WWTP to some sites north of the existing plant. Figure 4-1 highlights the existing WWTP and one of several potential new locations for the WWTP. Site location does not significantly impact any of the alternatives discussed here except for the parallel lagoon/activated sludge option; operating two different plants at two different sites would prove even more difficult and inconvenient to implement. Otherwise, the cost to construct and operate a new plant would not vary significantly if it were situated at the existing site or a new location. Of course, any expenses to purchase or acquire the land would be additional. Our understanding is that potential alternate sites may be donated to the City or sold at a substantial discount, minimizing the impact of land acquisition cost on this decision. Regardless, there are multiple factors to consider when discussing potential sites as listed and discussed below.

Figure 4-1: Grantsville WWTP service area, existing site, and potential alternative site.



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CITY OF GRANTSVILLE

WASTEWATER FEASIBILITY STUDY

FACILITY LOCATION ALTERNATIVES

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- Size – considers whether the site accommodate all the necessary facilities necessary. May also consider the need for sludge drying, sludge storage, or reuse/effluent water storage.
- Buffer space – in conjunction with proximity, a larger space provides larger buffer between facilities and potential future neighboring improvements, reducing the likelihood of complaints or aesthetic/odor issues.
- Proximity – considers where the site is located relative to homes, businesses, and what future development in the area might entail. Odors and complaints must be considered when locating the plant and considered during design.
- Cost – any costs to purchase/acquire land, handle title transfer and legal issues, and extend utilities (water, electricity, natural gas) and any access road installation must be added to the capital cost of the project.
- Collection System – considers how much of the service area can flow to the site via gravity versus requiring multiple collection system pump stations.
- Accessibility – considers how convenient the site is for operating staff, truck access (for deliveries and sludge hauling.

As discussed, the existing site has enough space for a 3 MGD plant and could potentially include ~50 acres of pond storage. This could theoretically provide from 100 to 150 million gallons of storage, enough for 30 to 50 days of winter storage at an ADF of 3 MGD. Any additional storage would need to be pumped to a different location. Thus, any new location would ideally be considerably larger to offer more storage. A new, larger site would also provide more buffer space between wastewater process basins (sources of odor) and future improvements. This decreases the chance of complaints if development occurs around the site.

In consideration of location and buffer space, a new location may be farther removed from development and less likely to have housing or commercial improvements encroach on its boundaries. The existing WWTP is not close to any improvements to date, but is fairly centrally located relative to other sites being considered to the north. As growth continues, it is likely that some development will be closer to the existing WWTP site.

Regarding cost, there is no inherent additional cost to utilizing the existing WWTP site. Alternate locations that have been discussed revolve around potential land donations to the City, which would minimize direct costs with land acquisitions. Other costs to connect the new site to utilities and extend sewage lines would need to be considered however.

As noted in Figure 4-1, a new site located farther north could extend the potential gravity collection service area. However, sewage from the existing collection area that is currently pumped to the WWTP would still need to be pumped to the new site. In addition, while it is convenient to reduce or even eliminate collection system pump stations, an "all gravity" collection system does not eliminate the energy cost and need for pumping. Even if all flow arrives at the plant via gravity, it must be pumped at the site to allow it to flow through the treatment process. Eliminating all pumping would require that the WWTP facility itself be installed 25-30+ feet below grade which is not practical. Thus, while reducing collection system pumps is a bit more convenient and offers some cost savings, it is overall a minor consideration. As stated, any new site located north would still require pumping from much of the existing service area, as well as a pump station at the site for any gravity flow. In contrast, expanding at the existing site would continue to utilize the two collection system lift stations, and would likely include at least one additional collection system lift station.

In conclusion, the recommended alternative in this study is the same regardless of whether the improvements are installed at the existing WWTP site or a new location. If the City is able to obtain a larger property (e.g. 150-200+ acres), especially one that may be more removed from potential development, it may be worth the effort to relocate the plant. Otherwise, a new location of similar size does not offer any advantageous that were considered in this analysis. This item merits additional consideration once specific sites have been confirmed.

4.3 Recommended Upgrade Alternative

All four alternatives discussed in Chapter 3 would successfully increase WWTP capacity and performance to meet these design criteria. After reviewing total 20-year NPV and discussing options with City staff and operators, the preferred alternative is upgrading to a new, 3 MGD

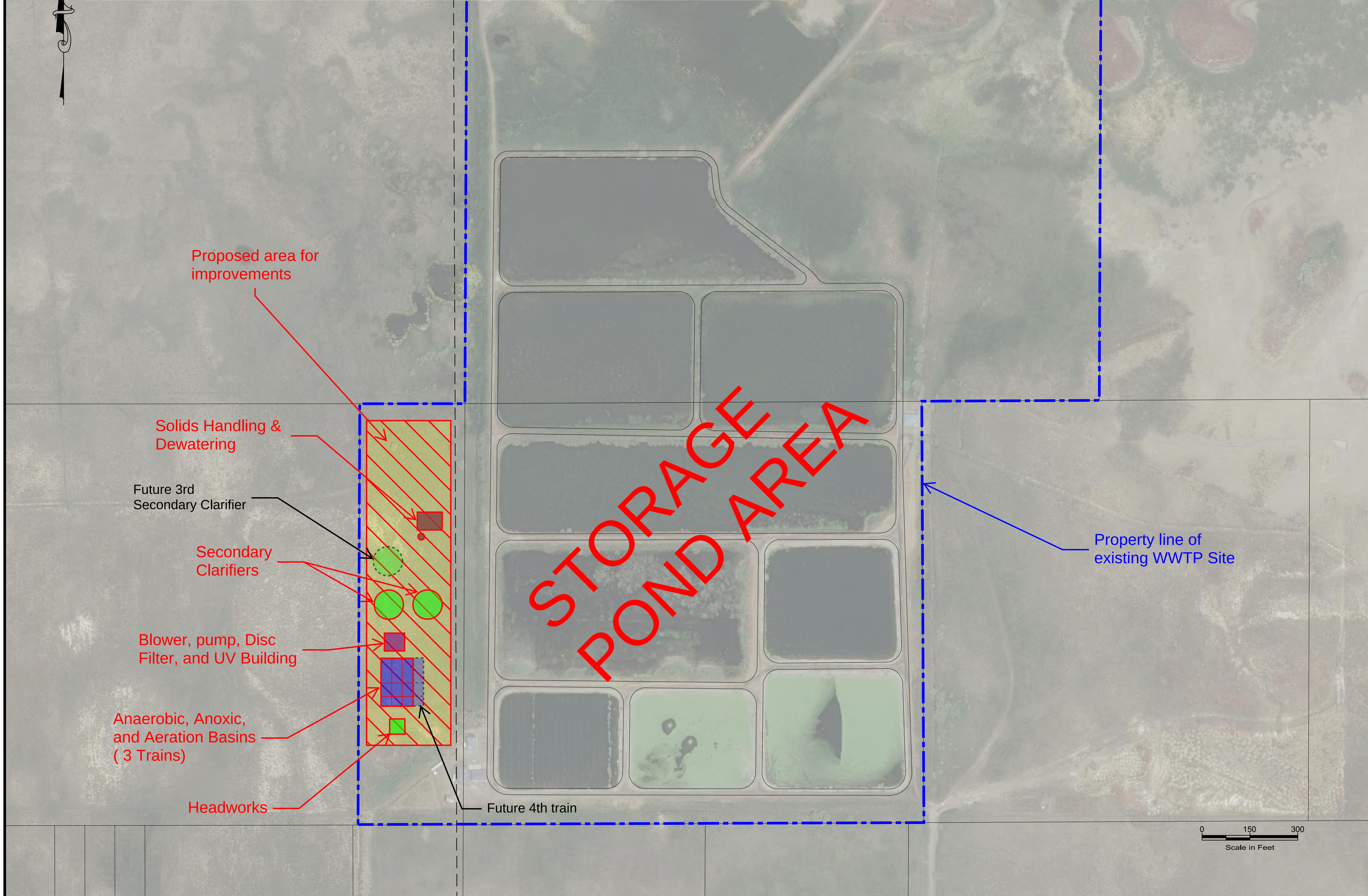
(ADF), 7 MGD (PHF) fine bubble diffuser activated sludge plant. Our analysis and review of options endorses this decision; it appears to be the most cost effective overall with the lowest capital and O&M costs. The technology offers easy expansion in the future for capacities beyond 3 MGD. Operators are familiar and comfortable with diffuser maintenance and operation.

To review, this alternative includes:

- New Headworks building including fine (6 mm) screens, screenings washpactors, grit removal, and grit washer/classifier. The building would include HVAC to comply with NEMA requirements and could equipped with odor control if desired.
- Anaerobic basins – equipped with mechanical or air-eductor mixers.
- Anoxic basins – equipped with mechanical or air-eductor mixers.
- Fine bubble diffuser aeration basins – equipped with sleeve or disc diffusers, sized per manufacturer recommendations to treat flow and loading design parameters.
- Blower equipment building to house blowers for the diffusers (and eductor mixers if applicable). This building could also serve as a new electrical room and could house other equipment such as tertiary disc filters, internal recycle pumps, and UV disinfection.
- Secondary clarifiers – two (2) 90-foot diameter clarifier tanks (with mechanisms) would be installed. Associated RAS pumps (and WAS pumps if applicable) could be housed in a nearby building that could share space with sludge dewatering equipment.
- Tertiary filtration to meet Type I reuse requirements

The new facility could be installed at the existing WWTP or relocated to a new parcel if the City obtains a large enough parcel to merit relocation. Planning for funding, equipment procurement, and design should commence within the next year to allow sufficient time to develop a complete design package and complete construction in time to meet time restraints associated with exceeding effluent P levels and to accommodate anticipated rapid growth over the next several years. A preliminary layout showing these improvements as the existing site is provided in Figure 4-2 for reference.

Figure 4-2: Preliminary 3 MGD fine-bubble aeration process site plan. Facilities for expansion beyond 4 MGD are also shown in dashed black outlines.



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