Arizona Water Student Design Competition

Goodyear, AZ Rainbow Valley Water Reclamation Facility Design Proposal

CENE 476, Fall 2023

Clear Treatment Inc.

Prepared By: Madysen Kambich, Gabrielle Dierking, Chelsie Fowler, Milford Begay, and Ayed Zayed Alnefaie

Prepared For: Dr. Jeffrey Heiderscheidt

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List of Abbreviations

AADF	Allowable Average Daily Flow
ADEQ	Arizona Department of Environmental Quality
ASU	Arizona State University
AZ	Arizona
BOD	Biochemical Oxygen Demand
EOPC	Engineer's Opinion of Probable Cost
EPA	Environmental Protection Agency
MGD	Million Gallons Per Day
NAU	Northern Arizona University
OSHA	Occupational Safety and Health Administration
RVWRF	Rainbow Valley Water Reclamation Facility
SDC	Student Design Competition
UofA	University of Arizona
WEF	Water Environment Federation
WRF	Water Reclamation Facility

1.0 Project Understanding

1.1 Project Purpose

The project's primary objective is to address the critical need for an advanced Water Reclamation Facility (WRF) in Goodyear, Arizona, with a specific focus on enhancing its wastewater treatment capabilities to produce reclaimed water suitable for non-potable reuse applications. The existing infrastructure in Goodyear falls short of meeting the escalating demands of the community, leading to environmental contamination due to inefficient wastewater treatment.

This project aims to significantly augment the treatment capacity of the facility, ensuring not only compliance with current regulations but also proactively addressing forthcoming environmental challenges. The optimization of the treatment process will encompass the removal of hazardous substances, heavy metals, and organic pollutants, thus playing a pivotal role in safeguarding public health and preserving the local ecosystem.

Furthermore, a key project objective is to prepare for participation in the Arizona (AZ) Water Student Design Competition (SDC). This prestigious competition, organized by the AZ Water Association and Water Environment Federation, serves as a platform for students from prominent Arizona institutions, including Northern Arizona University (NAU), Arizona State University (ASU), and the University of Arizona (UofA), to highlight their skills in designing and improving water treatment facilities. The project encompasses a holistic analysis, including treatment processes, pump selection, flow requirements, and life-cycle cost analysis, all geared towards meeting the demands of both the competition and the real-world challenges of wastewater treatment.

1.2 Project Background

The water reclamation facility that was chosen by the Arizona Water Student Design Competition for redesign is in Goodyear, Arizona. The WWTP that was selected for this year's project is the Rainbow Valley Water Reclamation Facility (RVWRF) which is owned by the City of Goodyear. This facility is located fifteen miles southeast of downtown Goodyear [1].

Figure 1.1 shows where the project is located within the State of Arizona. The facility is positioned southwest of the City of Phoenix.

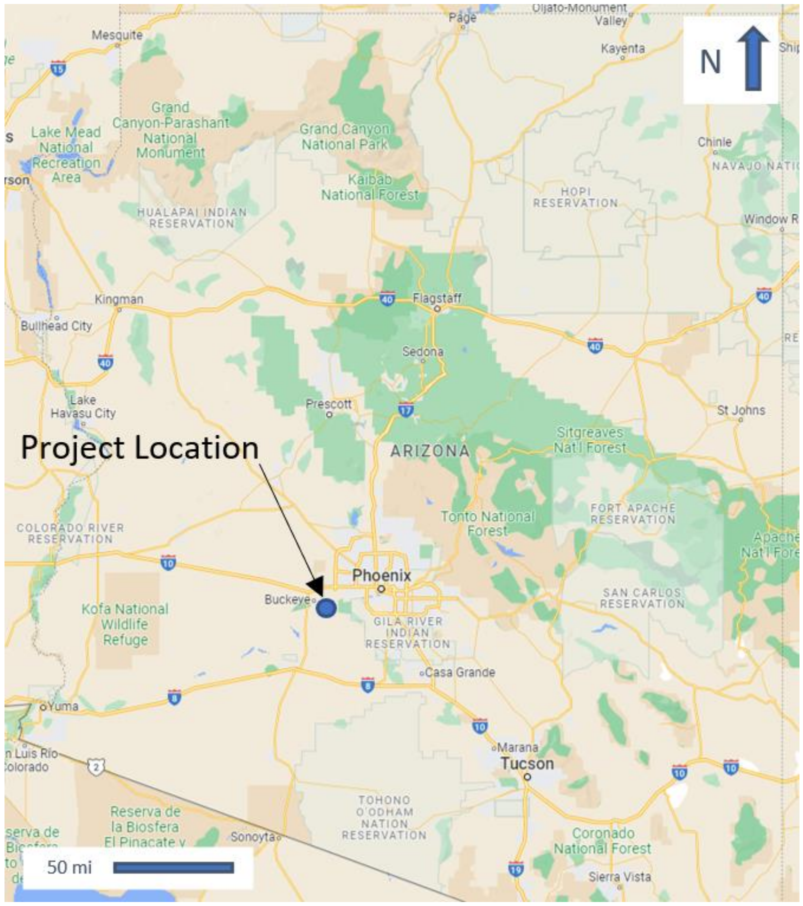

Figure 1.1: Project Location Map

Figure 1.2 shows where the project is located within the City of Phoenix. The facility is positioned southwest of the City of Goodyear.

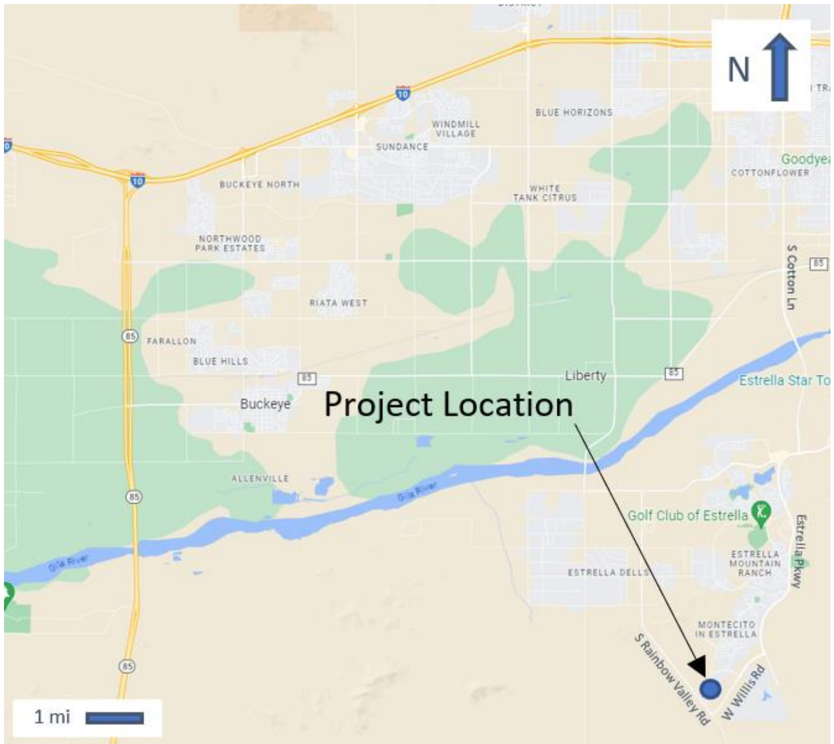

Figure 1.2: Project Vicinity Map

Figure 1.3 shows the project site. The project site can be accessed from South Rainbow Valley Road.

Figure 1.3: Project Site Map

The facility has an allowable average daily flow (AADF) of 0.75 million gallons per day (MGD) [1].The site utilizes an activated sludge process. This type of treatment includes the following processes:

- Influent screening- large screens remove the large solids from the influent such as rags and biosolids before entering the aeration tank.
- Aeration that includes mixed internal liquid recycle- Aeration tank utilizes microorganisms to decrease the biochemical oxygen demand (BOD) in the wastewater.

- Secondary sedimentation- Allows the solids that remain in the wastewater from the previous process to settle out before the effluent enters the tertiary filters.
- Tertiary filters- Tertiary filtration is the last step of the process before disinfection. This step removes nitrogen and phosphorus from the wastewater.
- Chlorination- The process of chlorination is vital for removing viruses and bacteria from the water that the previous processes were not able to remove. The pathogens that are present in wastewater can cause waterborne illness if the wastewater is released from the facility before any sort of disinfection.
- Dechlorination- Dechlorination is required after chlorination to remove the chlorination byproducts that could cause potential health issues if not removed from the water.

This facility treats the sludge that is created throughout the activated sludge process with a centrifuge. The centrifuge is used for dewatering the sludge and does so by quickly rotating the sludge in a cylindrical shaped bowl to separate the solids from the effluent in the wastewater sludge. The solids that are left over after the centrifuge are disposed of by being hauled to a landfill offsite. The treated effluent from the facility is reused for irrigation by being pumped to a non-potable water distribution system. The irrigation is used on Estrella Mountain Golf Course and Canta Mia Lakes [1].

1.3 Technical Considerations

The design of a water reclamation facility must follow critical steps to result in a successful and effective facility. Technical considerations for the process are briefly described in the following section.

1.3.1 Codes and Regulations

Standard codes and regulations have been put in place for wastewater by federal, state, and local governments. The Environmental Protection Agency (EPA) acts as the federal entity for effluent standards. Based on location, the state and local regulations for wastewater differ, so researching those standards is crucial. The Arizona Department of Environmental Quality (ADEQ) specifies effluent standards for the state. The City of Goodyear’s local standards will also be followed.

1.3.2 Wastewater Data

When beginning the design of a water reclamation plant, data about the incoming wastewater needs to be collected. A volume estimation of the incoming influent per day is required to choose a design capacity that the treatment tanks’ dimensions will be designed for. The estimated volume takes into consideration the population of the location the facility will be serving, along with any industrial or agricultural wastewater that will come to the plant. Historical wastewater data is necessary to determine what contaminants will be in the influent. Once the contaminants are identified, proper treatments can be designed.

1.3.3 Site Data

Site data of the physical location of the plant will assist in the design of the treatment facility. The topography of the site will help determine the layout of the new facility. It is optimal to use gravity to move the wastewater through the facility. Doing so will cut down on operation costs by reducing the number of pumps needed to move the water. The local environment of the area needs to be taken into consideration as well. Factors such as the climate, geography, and geology are crucial to understand to design an effective and efficient plant.

1.3.4 Preliminary and Primary Treatment

Preliminary and primary treatments are the first steps in any water reclamation facility. The objective of these treatments is to remove nonhomogenizable solids through physical processes. These processes include bar screens, comminutors, grit chambers, and settling tanks. Removing larger solids is essential to ensure secondary treatment equipment does not get damaged. A preliminary and primary treatment option will be designed based on the anticipated volume and flow rate of influent into the facility and the typical volume of the solids in the area.

1.3.5 Secondary Treatment

Secondary treatment consists of biological processes that remove most of the BOD from the primary treatment effluent. Secondary treatments differ between plants due to the contaminants in the wastewater and the requirements of the final effluent. With the main objective of this treatment process being the reduction in biochemical oxygen demand, microorganisms are utilized in many ways to break down organic matter. Based on the needs of the area and present contaminants in the wastewater, secondary treatments will be designed accordingly. The volume of influent will be taken into consideration to determine the size of treatment tanks. The levels of contaminants in the influent will also be considered when determining the specific secondary treatment that will be implemented in the extension of the facility.

1.3.6 Advanced Treatment

Advanced treatment can be a physical, biological, or chemical process that removes remaining nutrients and inorganic pollutants in the remaining influent. This step can also include disinfection before the final effluent is released to its destination. The objective of this treatment is to comply with expectations of the effluent standards for the uses of the water once it leaves the plant. Determining which treatment should be implemented whether it is a physical, biological, or chemical treatment will be based on the remaining contaminants left in the water after the secondary treatment processes.

1.3.7 Solid Waste Management

While water reclamation facilities produce clean water, they also produce solid waste that needs to be disposed of. The solids taken out of the water from the primary treatment are typically hauled off site to a landfill. Other solid wastes that need to be dealt with can come from various secondary treatments. All the sludge that is produced in the facility needs treatment before being disposed of or sold for reuse. The sludge treatment process typically involves thickening, anaerobic digestion, and dewatering of the sludge. These treatments will be designed based on the estimated sludge volume that is produced by the facility and potential reuse options.

1.3.8 Hydraulic Analysis

A hydraulic analysis of the plant design will be completed to determine the necessary hardware to convey the water through the facility. Once the pipe sizes and pumps have been determined, a hydraulic profile will be made. Hydraulic profiles are prepared at peak and average design flows, and the minimum initial flow. The head loss throughout the plant is calculated to ensure the proper conveyance throughout the plant.

1.3.9 Life Cycle Cost Analysis

To understand the expected cost the facility will generate, a life cycle cost analysis must be completed. This cost analysis includes the initial construction costs, maintenance costs, and operation costs. The construction costs will be determined with an Engineer's Opinion of Probable Cost (EOPC). The EOPC will include quantities of all materials needed and a unit price for each line item which includes labor costs. Maintenance costs will be determined by the frequency and cost of the facility's maintenance needs throughout its lifetime. Finally, the operation costs will include the cost of energy needed to power the facility and the cost of plant personnel.

1.4 Potential Challenges

The process of designing an expansion for a WRF involves addressing and incorporating potential challenges that may arise during design.

1.4.1 Time

The design project has different deadlines that the team needs to keep track of. The AZ water competition has multiple deliverables that need to be completed by a fixed date. There could potentially be changes to those deadlines resulting in modifications needing to be made in the team's design schedule. The team would need to continue practicing effective time management, remain adaptable, and regularly keep themselves updated on prospective changes.

1.4.2 Land Area

Another challenge that could interfere with the processes is the limited land area of the facility. Any improvement must be made within the borders of the area and adjusted to the geographic location. The project requires an expansion of the facility, so the layout of the additional structures needs to be planned out carefully to stay within the site location. Further research among the team on the land area and any restrictions will be completed to ensure that the facility is within those parameters.

1.4.3 Construction Phasing

The water reclamation facility needs to remain operational while the expansion of the facility is being constructed. Construction phasing will need to be completed to keep the facility running. Phasing the construction will be a potential challenge because of the small land area that is provided for the new development and the long construction time that will be required for this expansion. The construction phasing will require detailed scheduling, active communication, and excellent time management to be successful.

1.5 Stakeholders

The project stakeholders include the residents of the city of Goodyear, the federal and state regulatory agencies, and the community in the direct vicinity of the project. The local community will be served by the water reclamation facility and will be providing the influent flow into the facility. The community may also be impacted by way of increased wastewater fees that will be attributed to the expansion of the facility and to the increase in operations.

The state regulation agencies will be involved with the project both during and after its completion. Agencies such as EPA and ADEQ will provide oversight to the project to ensure that the operations of the project and the effluent produced by the reclamation facility meet set regulations and standards. The project operations will also have to follow guidelines set by The Occupational Safety and Health Administration (OSHA) to ensure the safety and well-being of the facility staff.

An additional stakeholder is the residents, communities and businesses that are directly adjacent to the project site and the environment around it. The project construction will involve clearing vegetation from the site and distributing existing soil to build foundation structures. The presence of the facility may also be a source of foul odor that would be unpleasant for any residents in the area or any commuters passing by the project location. The noise produced during construction and the day-to-day operations of the plants may also affect the surrounding residents in the community.

The non-potable water produced at the facility is used on Estrella Mountain Golf Course and Canta Mia Lakes. The community that uses the golf course or visits Canta Mia Lakes are also stakeholders in this project.

2.0 Scope of Services

The project scope for the Goodyear Water Reclamation Facility expansion can be divided into several major tasks and subtasks, as outlined below.

2.1 Task 1: Preliminary Assessment

A preliminary assessment of the project will be conducted before continuing with the expansion design. This preliminary assessment will include the initial research of additional treatment processes and the research of federal, state, and local water reclamation regulations that apply to the design project.

2.1.1 Task 1.1: WEF Application

The WEF Application subtask involves preparing for participation in the Water Environment Federation (WEF) Student Design Competition. This entails reviewing the competition requirements, guidelines, and deadlines. The team will collaborate to develop a comprehensive and competitive application for entry into the AZ Water Spring 2024 Student Design Competition.

2.1.2 Task 1.2: Additional Treatments Research

Extensive research will be conducted on advanced wastewater treatment processes and additional treatment technologies beyond the standard water treatment methods. This research will focus on identifying innovative solutions to enhance the treatment process and improve the quality of reclaimed water. The goal is to explore innovative technologies and methodologies that can be incorporated into the project to optimize the facility's performance, operation, and environmental compliance.

2.1.3 Task 1.3: Research Regulations

This task involves thorough research into federal, state, and local regulations governing wastewater treatment and water reclamation. The team will focus on understanding the EPA standards, ADEQ regulations, and City of Goodyear's local standards. This research is essential for ensuring that the project complies with all relevant regulations and standards, contributing to the facility's successful operation and environmental compliance.

2.2 Task 2: Site Assessment

The site will be evaluated to discern any constraints, restrictions, and existing conditions that would have an impact on the project. The team will use data provided by the WEF competition and will conduct a virtual site visit to gather additional information regarding the project vicinity.

2.2.1 Task 2.1: Site Visit

The team will attend a virtual site visit to collect information on the existing conditions of the site including the operations currently in place. Information gathered will include the dimensions of tanks, structures, and treatment processes.

2.2.2 Task 2.2: Data Analysis

Data about the site including the influent volume, the contaminants present in the water, and the level of contamination will be provided by the WEF competition guidelines. Data provided also includes the population size of the community, the daily max flow, the average flow, and permit limits for effluent. The team will analyze the given data to determine the most suitable treatment options and design the project accordingly.

2.2.3 Task 2.3: Determine Topography

Data of the existing topography of the project vicinity is provided by the WEF Competition. The data will be analyzed to determine the constraints and restrictions that apply to any planned expansion and construction at the site. Topographical data of the site will be provided, and Civil3D will be utilized to create a topographic map of the project site.

2.3 Task 3: Treatment Design

Based on the competition-provided data, the team will build an expansion to the water reclamation facility and complete additional research on the various technologies employed in wastewater treatment to develop alternatives. The alternatives will be further examined and narrowed down to the most efficient option.

2.3.1 Task 3.1: Determine Plant Requirements

After reviewing the site assessment, the team will determine the water reclamation facility requirements based on the treatment design process. Items that would need to be found include the effluent requirements and water source conditions based on the WEF competition project.

2.3.2 Task 3.2: Preliminary Treatment

Preliminary treatment focuses on removing large solids and larger particles from the influent. The team will research different preliminary treatment technologies and analyze which option will be the most efficient.

2.3.2.1 Task 3.2.1: Determine Criteria

The criteria used to choose the best alternative will be determined when researching the different preliminary treatment options and regulations.

2.3.2.2 Task 3.2.2: Develop Preliminary Treatment Alternatives

The team will consider several types of treatment options based on competition requirements and determined criteria.

2.3.2.3 Task 3.2.3: Select Best Alternative

The team will make a decision matrix with the preliminary treatment technology design methods to evaluate which alternative will be used. The matrix will consist of a few alternatives and be narrowed down to the best design solution.

2.3.3 Task 3.3: Primary Treatment

Primary treatment removes material that floats to the surface or settles out at the bottom of the primary clarifier by gravity. The team will research different primary treatment technologies and analyze which option will be the most efficient.

2.3.3.1 Task 3.3.1: Determine Criteria

After examining the many initial treatment alternatives and rules, the selection criteria for the optimal solution will be established.

2.3.3.2 Task 3.3.2: Develop Primary Treatment Alternatives

The team will evaluate several treatment methods in accordance with the competition's requirements and predetermined criteria.

2.3.3.3 Task 3.3.3: Select Best Alternative

The team will make a decision matrix with the primary treatment technology design methods to evaluate which alternative will be used. The matrix will consist of a few alternatives and be narrowed down to the best design solution.

2.3.4 Task 3.4: Secondary Treatment

Secondary treatment is the process of removing soluble organic matter and suspended solids. This treatment includes physical, chemical, and/or biological designs.

2.3.4.1 Task 3.4.1: Determine Criteria

Researching the many preliminary and primary treatment options and regulations will provide the criteria used to select the best secondary treatment.

2.3.4.2 Task 3.4.2: Develop Secondary Treatment Alternatives

The development of design choices for a secondary treatment will focus on reducing the amount of organic matter in the wastewater through a biological process. The team will research technologies based on influent and effluent water conditions.

2.3.4.3 Task 3.4.3: Select Best Alternative

Using a decision matrix, the team will evaluate the design alternatives and choose the best option for the potential final solution.

2.3.5 Task 3.5: Advanced Treatment

Advanced treatment treats the influent further by implementing different advanced processes that remove nutrients and other constituents that prevent reuse of effluent.

2.3.5.1 Task 3.5.1: Determine Criteria

While investigating the many advanced treatment alternatives, the criteria that will be utilized to select the best alternative will be determined.

2.3.5.2 Task 3.5.2: Develop Advanced Treatment Alternatives

Design alternatives for an advanced treatment will be researched based on the estimated remaining contaminants in the water after the secondary treatment.

2.3.5.3 Task 3.5.3: Select Best Alternative

Once all advanced treatment alternatives have been researched, a decision matrix will be utilized to select the design the team will move forward with. Design constraints and criteria will be the deciding factors that will lead to the chosen design.

2.3.6 Task 3.6: Disinfection

After the water has been filtered, the water can be disinfected. The team will determine which methods would be best for the water reclamation facility and design the process.

2.3.6.1 Task 3.6.1: Determine Criteria

After investigating the many disinfection processes, the selection criteria for the optimum alternative will be established.

2.3.6.2 Task 3.6.2: Develop Disinfection Alternatives
Design alternatives for the disinfection stage of the process will be determined utilizing the predetermined criteria.

2.3.6.3 Task 3.6.3: Select Best Alternative
A decision matrix will be used to determine the best disinfection alternative for the facility. The criteria and limitations of the design will be the decisive elements that determine which design is selected.

2.3.7 Task 3.7: Solids Management
One of the major factors in designing a water reclamation facility includes the treatment and management of sludge. The team will have to design a solid waste management plan.

2.3.7.1 Task 3.7.1: Determine Criteria
Researching the first treatment options and regulations will provide the criteria used to select the best form of solids management.

2.3.7.2 Task 3.7.2: Develop Solids Management Alternatives
Based on established criteria, the team will evaluate several solid waste treatment options.

2.3.7.3 Task 3.7.3: Select Best Alternative
The optimum option for solid management in the water reclamation facility will be chosen using a decision matrix. The determining variables that result in the selected design will include the predetermined criteria.

2.4 Task 4: Final Design
A final design for the expansion of the facility will be completed. The final design will include a new site layout, a hydraulic analysis, and an economic analysis.

2.4.1 Task 4.1: Site Layout
Once a final design of the expansion to the facility has been completed, the team will produce a site layout which will include the expansion and the existing facility. The site layout will show the placement of the new treatments alongside the existing facility.

2.4.2 Task 4.2: Hydraulic Analysis
The team will perform a hydraulic analysis of the facility. The hydraulic analysis will consist of a system analysis which will lead to pump selection and tank elevation and positioning.

2.4.2.1 Task 4.2.1: System Analysis

A hydraulic profile of the facility design will be created for all main paths through the plant and utilize changes in tank elevations to maximize gravity flow through the plant.

2.4.2.2 Task 4.2.2: Pump Selection

Based on the flow and head loss needs of the facility, a pump and pipe system will be selected.

2.4.3 Task 4.3: Construction Phasing

For the existing plant to remain open in operation at the current capacity, a construction phasing plan will be developed for the expansion design. The construction phasing plan will ensure water will continue to be treated throughout the entire construction process. This includes not only the new construction, but also any demolition or modifications to the existing infrastructure.

2.4.4 Task 4.4: Economic Analysis

The Life Cycle Cost Analysis portion of this project will include determining the cost of the project. The cost of the project will include the cost of construction, operation, maintenance, costs of the facility, and any revenue from the facility from selling the reclaimed solids.

2.4.3.1 Task 4.3.1: Construction Cost

This construction cost task must be completed to determine the cost for materials, labor, and equipment required to complete the construction of the facility expansion. This task will be completed by examining various sources like past projects, technical advisors, and a website called RSMeans. RSMeans provides cost data for specific types of construction, types of labor, locations, and certain quarter releases to account for inflation.

2.4.3.2 Task 4.3.2: Maintenance and Operation Costs

The operation costs will encompass all day-to-day operation expenses of the facility. The maintenance costs will account for money spent to maintain and fix any of the equipment at the facility that may be broken or need to be replaced. The maintenance costs may fluctuate based on how often certain equipment is used and the life span of the specific equipment. Operation costs may fluctuate based on the number of employees the facility will require, the amount of power needed to run the plant, and the costs related to getting the influent into the facility and the effluent out of the facility. These costs can be determined by researching the operation and maintenance costs of other treatment facilities in the State of Arizona.

2.4.3.3 Task 4.3.3: Life Cycle Cost Analysis

The life cycle cost of the facility will be determined using the initial construction costs, lifespan of the facility, and the expected use of the facility. The cost will also include maintenance and operation costs over the lifespan of the facility. The life cycle cost should also account for inflation.

2.5 Task 5: Project Impacts Analysis

This section will analyze the impacts of the project which will include social, environmental, and economic aspects. These assessments will provide valuable insights into the impacts of the project for various stakeholders and the surrounding community.

2.6 Task 6: Project Deliverables

There are multiple deliverables due for the capstone project throughout the spring semester. The deliverables are broken up into four stages of progress: 30%, 60%, 90% and 100%, as well as competition deliverables**.**

2.6.1 Task 6.1: 30% Deliverable

The 30% deliverable includes the 30% design report and presentation. The design report and presentation at the 30% stage will include the completion of Task 1: Preliminary Assessment and Task 2: Site Assessment.

2.6.2 Task 6.2: 60% Deliverable

The 60% deliverable includes the 60% design report and presentation. The design report and presentation at the 60% stage will include the completion of Task 3: Treatment Design, Task 4: Final Design, and Task 5: Project Impacts Analysis.

2.6.3 Task 6.3: 90% Deliverable

The 90% deliverable includes the 90% design report, draft website, and draft final presentation. All technical tasks included in the project must be completed for this deliverable to be successful.

2.6.4 Task 6.4: 100% Deliverable

All tasks, the design report, presentation, and the final project website must be completed for the 100% deliverable.

2.6.5 Task 6.5: Competition Final Report

A final design report is required for the competition.

2.6.6 Task 6.6: Competition Final Presentation

A final oral presentation is required for the competition.

2.7 Task 7: Project Management

The team will meet regularly to report and review the progress and work necessary to complete the project.

2.7.1 Task 7.1: Meetings

The project team will meet regularly to check in on the team's collective progress on the project. There will be one minimum team meeting per week. The team will also meet regularly with the TA to discuss the project and ensure that the work is on schedule. There are two meetings with the TA required for the fall semester.

2.7.2 Task 7.2: Schedule Management

The project team will plan and manage time to ensure that major project milestones and deliverables are completed on schedule. The team will regularly review what tasks are needed from each team member and will complete the needed tasks as planned. The project schedule will be updated if needed to accommodate for any unforeseen circumstances or any additional requirements or work that may need to be addressed as the project progresses.

2.7.3 Task 7.3: Resource Management

The team will track work hours spent on project tasks and progress. Tracking will also involve the project design budget. This will be done to ensure that the project is completed within budget.

2.8 Exclusions

The team will be responsible for the scope of work listed above. The team will not be responsible for how the expansion will be constructed, any lab work, transportation of waste or wastewater, environmental studies, obtaining permits, or operations of the facility. The team will not perform any community outreach about the project. The team will not create construction drawings for the plant or process modifications. The team will not perform any field survey or sampling work.

3.0 Schedule

The team developed a preliminary schedule for the project.

3.1 Schedule Summary

The schedule starts on December 16th, 2023, and ends on May 7th, 2024. The schedule is ninety-eight working days which does not include weekends or spring break which is May 11th-15th. The schedule includes the project's seven major tasks. These tasks include a preliminary assessment, site assessment, treatment design, final design, project impacts, deliverables, and project management. Major deliverables for this project are the milestones on the schedule. These milestones include the 30% deliverable, 60% deliverable, 90% deliverable, 100% deliverable, competition final report, and the competition oral presentation. This schedule is subject to change once the design begins in January 2024. The schedule can be found in Appendix A.

3.2 Critical Path

The critical path on the schedule is the path of tasks that will determine when the project is finished. This path is crucial to the project because any task in the critical path cannot exceed the set duration that is currently set. If the tasks in the critical path are not completed on time, the project will not be finished by the required deadline. To ensure that the tasks within the critical path are completed on time, the team will utilize non-working days in the schedule such as weekends and spring break if needed.

4.0 Staffing Plan

4.1 Staff Titles

The staffing for the project is comprised of a Senior Engineer, Engineer, Engineer in Training, and an Engineering Intern.

Table 4.1 below shows the abbreviation for each staff position that will be used in the remaining tables.

Table 4.1: Staff Abbreviations

Position Title	Abbreviation
Senior Engineer	SENG
Engineer	ENG
Engineer in Training	EIT
Engineering Intern	INT

4.2 Staff Qualifications

4.2.1 Senior Engineer Qualifications

The Senior Engineer is responsible for overseeing the project. They will conduct the final review of major tasks within the project and have the final say on whether the design is effective. The senior engineer will also interact with clients and take charge of project management to ensure the project is completed on time and within budget.
The qualifications of the Senior Engineer are:

- Bachelor's of Science in Civil or Environmental Engineering
- Professional Engineering License (PE) in Civil or Environmental Engineering
- At least 10 years of experience as a professional engineer in the industry

4.2.2 Engineer Qualifications

The Engineer is in charge of working on the technical components of the project such as the development of unique design alternatives and drafting of plans. They will be responsible for completing about half of the technical work.
The qualifications of the Engineer are:

- Bachelor's of Science in Civil or Environmental Engineering
- Professional Engineering License (PE) in Civil or Environmental Engineering
- At least 5 years of experience as a professional engineer in the industry
- Proficiency in Civil3D

4.2.3 Engineer in Training Qualifications

The Engineer in Training is a recent college graduate with a Bachelor's of Science in Civil or Environmental Engineering. The EIT will aid the engineer in technical designs, research, and drafting. The Engineer and Senior Engineer will review their work.
The qualifications of the Engineer in Training are:

- Bachelor's of Science in Civil or Environmental Engineering
- Passed the Fundamentals of Engineering Exam (FE)
- Obtained an Engineer in Training certificate
- Proficiency in Civil3D

4.2.4 Engineering Intern Qualifications

The Engineering Intern is either a recent college graduate or is soon to graduate with a Bachelor's of Science in Engineering. They will collaborate with the Engineer and Engineer in Training on technical designs, research, drafting, and any other work that they are asked to complete.
The qualifications of the Engineering Intern are:

- Working towards a Bachelor's of Science in Civil or Environmental Engineering
- On track to graduate in at least two years
- Preferred to have a minimum GPA of 3.0

4.3 Staffing Hours

Utilizing the project schedule, a staffing table was created. This table displays the number of hours each staff member will spend completing each task. The total number of hours the staff members will work on this project is nine hundred hours. The staffing table can be found in Appendix B.

Table 4.2 below shows a summary of hours for every major task and staff position.

Table 4.2: Summary of Major Task Hours

Task	SENG (hr)	ENG (hr)	EIT (hr)	INT (hr)	Total (hr)
Task 1: Preliminary Assessment	1	1	40	35	**77**
Task 2: Site Assessment	3	13	11	5	**32**
Task 3: Treatment Design	24	105	214	67	**410**
Task 4: Final Design	14	45	85	16	**160**
Task 5: Project Impacts Analysis	1	4	0	0	**5**
Task 6: Project Deliverables	20	35	35	31	**121**
Task 7: Project Management	25	30	20	20	**95**
Total Hours	**88**	**233**	**405**	**174**	**900**

5.0 Cost of Engineering Services

The expected total cost for engineering services for the project is $138,777. The cost consists of the total expected hours of the Senior Engineer, Engineer, Engineer in Training, and Engineering Intern along with two one-day trips down to Phoenix, Arizona. The billing rates for each position were determined based on the employee's hourly rate and benefits, the overhead cost of the company, and profit. The breakdown of the billing rates can be found in Appendix C. Each billing rate was then multiplied by the expected number of hours for each position. The total cost for personnel is $136,482. The cost per mile for the day trips were found using information provided by NAU Transportation Services. The total cost for travel expenses is $675.50. The total cost for supplies was $1060.

Table 5.1 below shows the total cost of engineering services for this project.

Table 5.1: Cost of Engineering Services

1.0 Personnel	Classification	Hours	Rate, $/hr	Cost, $
	SENG	88	250	22,000
	ENG	233	190	44,270
	EIT	405	142	57,510
	INT	174	73	12,702
			Personnel Sub-total	**136,482**
2.0 Travel	Classification	Items	Cost Per, $	Cost, $
	Car Rental	3 Days	$34/day	102
	Mileage	2 Trips, 300 Miles Each	$0.40/mi	240
	Hotel	4 Rooms, 1 Night	113/night	452
	Per Diem	6 Persons, 2 Days	$36.75/person/day	441
			Total Sub-total	**1,235**
3.0 Supplies	Classification	Items	Cost Per, $	Cost, $
	Computer Lab	10 days	$100/day	1,000
	3D Printing	500 grams	$0.12/gram	60
			Supplies Sub-total	**1,060**
Total				**138,777**

6.0 References

[1] A. W. Association, "2023-2024 AZWA Student Design Competition- Competition Details & Prompt Packet".

Appendices

Appendix A: Gantt Chart

Appendix B: Staffing Hours

Task	SENG	ENG	EIT	INT	Total Task Hours
Task 1: Preliminary Assessment					
Task 1.1: WEF Application	1	1			2
Task 1.2: Additional Treatments Research			20	25	45
Task 1.3: Research Regulations			20	10	30
Task 2: Site Assessment					
Task 2.1: Site Visit	3	3	3	3	12
Task 2.2: Data Analysis		5	5		10
Task 2.3: Determine Topography		5	3	2	10
Task 3: Treatment Design					
Task 3.1: Determine Plant Requirements		1	4		5
Task 3.2: Preliminary Treatment					
Task 3.2.1: Determine Criteria		3	5	2	10
Task 3.2.2: Develop Preliminary Treatment Alternatives		8	17	5	30
Task 3.2.3: Select Best Alternative	2	2			4
Task 3.3: Primary Treatment					
Task 3.3.1: Determine Criteria		4	7	4	15
Task 3.3.2: Develop Primary Treatment Alternatives		10	35	10	55
Task 3.3.3: Select Best Alternative	5	5			10
Task 3.4: Secondary Treatment					
Task 3.4.1: Determine Criteria		4	8	4	16
Task 3.4.2: Develop Secondary Treatment Alternatives		10	35	10	55
Task 3.4.3: Select Best Alternative	5	5			10
Task 3.5: Advanced Treatment					
Task 3.5.1: Determine Criteria		4	8	4	16
Task 3.5.2: Develop Advanced Treatment Alternatives		10	35	10	55
Task 3.5.3: Select Best Alternative	5	5			10
Task 3.6: Disinfection					
Task 3.6.1: Determine Criteria		3	5	4	12
Task 3.6.2: Develop Disinfection Alternatives		10	25	5	40
Task 3.6.3: Select Best Alternative	3	3			6
Task 3.7: Solids Management					
Task 3.7.1: Determine Criteria		4	5	4	13
Task 3.7.2: Develop Solids Management Alternatives		10	25	5	40
Task 3.7.3: Select Best Alternative	4	4			8
Task 4: Final Design					
Task 4.1: Site Layout	4	6	10		20
Task 4.2: Hydraulic Analysis					
Task 4.2.1: System Analysis	5	10	25	5	45
Task 4.2.2: Pump Selection	3	5	15	2	25
Task 4.3: Construction Phasing	2	8	10		20
Task 4.4: Economic Analysis					
Task 4.4.1: Construction Cost		10	10	5	25
Task 4.4.2: Maintenance and Operation Costs		3	10	2	15
Task 4.4.3: Life Cycle Cost Analysis		3	5	2	10
Task 5: Project Impacts Analysis					
Task 5: Project Impacts Analysis	1	4			5
Task 6: Project Deliverables					
Task 6.1: 30% Deliverable	2	5	5	5	17
Task 6.2: 60% Deliverable	2	5	5	5	17
Task 6.3: 90% Deliverable	4	10	10	6	30
Task 6.4: 100% Deliverable	4	5	5	5	19
Task 6.5: Competition Final Report	4	5	5	5	19
Task 6.6: Competition Final Presentation	4	5	5	5	19
Task 7: Project Management					
Task 7.1: Meetings	15	20	20	20	75
Task 7.2: Schedule Management	5	5			10
Task 7.3: Resource Management	5	5			10
Subtotal	**88**	**233**	**405**	**174**	
Total Person Hours					**900**